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Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience

Report of the UN Chernobyl Forum Expert Group "Environment" (EGE)

August 2005

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FOREWORD

The explosion on 26 April 1986 at the Chernobyl Nuclear Power Plant located just 100 km from the city of Kyiv in what was then the Soviet Union and now is Ukraine, and consequent ten days' reactor fire resulted in an unprecedented release of radiation and unpredicted adverse consequences both for the public and the environment. Indeed, the IAEA has characterized the event as the "foremost nuclear catastrophe in human history" and the "largest regional release of radionuclides into the atmosphere".

Massive radioactive contamination forced the evacuation of more than 100,000 people from the affected region during 1986, and the relocation, after 1986, of another 200,000 from Belarus, the Russian Federation and Ukraine. Some five million people continue to live in areas contaminated by the accident and have to deal with its environmental, health, social and economic consequences. The national governments of the three affected countries, supported by international organizations, have undertaken costly efforts to remedy contamination, provide medical services and restore the region's social and economic well-being.

The accident's consequences were not limited to the territories of Belarus, Russia and Ukraine but resulted in substantial transboundary atmospheric transfer and subsequent contamination of numerous European countries that also encountered problems of radiation protection of their populations, although to less extent than the three more affected countries.

Although the accident occurred nearly two decades ago, controversy still surrounds the impact of the nuclear disaster. Therefore the IAEA, in cooperation with FAO, UNDP, UNEP, UN-OCHA, UNSCEAR, WHO and The World Bank, as well as the competent authorities of Belarus, the Russian Federation and Ukraine, established the Chernobyl Forum in 2003. The mission of the Forum was — through a series of managerial and expert meetings — to generate "authoritative consensual statements" on the environmental consequences and health effects attributable to radiation exposure arising from the accident as well as to provide advice on environmental remediation and special health care programmes, and to suggest areas where further research is required. The Forum was created as a contribution to the United Nations' ten years strategy for Chernobyl, launched in 2002 with the publication of *Human Consequences of the Chernobyl Nuclear Accident – A Strategy for Recovery.*

In 2003-2004, two groups of experts from twelve countries, including Belarus, Russia and Ukraine, and from relevant international organizations have assessed the accident'senvironmental and health consequences. In early 2005, the group "Environment," coordinated by the IAEA, and the group "Health," coordinated by the WHO, have presented their reports for Forum consideration. Both reports were considered and approved by the Forum at its meeting on 18-20 April 2005. This meeting also decided, *inter alia*, 'to consider the approved reports ... as a common position of the Forum members, i.e., of the eight United Nations organizations and the three more affected countries, regarding environmental and health consequences of the Chernobyl accident, as well as recommended future actions, i.e., as a consensus within the United Nations system'.

This report presents the findings and recommendations of the Chernobyl Forum concerning environmental effects of the Chernobyl accident. The Forum's report considering health effects is in process of publication under WHO responsibility. The environmental group of experts was chaired by Dr. Lynn Anspaugh from the University of Utah, USA; the scientific secretary of this group and of the whole Chernobyl Forum activity was Dr. Mikhail Balonov of the Division of Radiation, Transport and Waste Safety, IAEA. In all cases the scientists from the UN organisations, the international community, and the three more affected countries have been able to reach consensus in the preparation of their respective documents. After approval by the members of the Forum, this report is the result of that process.

CONTENTS

3.1.2. National radiological criteria and standards

Limitations of human exposure caused by the Chernobyl accident, including standards for radionuclides in food, drinking water, timber, etc., were introduced soon after the accident firstly by the USSR, but also by many European countries, i.e., Nordic countries, EU countries and Eastern European countries (UNSCEAR 1988).

In accordance with the Standards of Radiation Safety (USSR Ministry of Health 1977) in force in 1986, the USSR Ministry of Health introduced a temporary limit of average equivalent whole body dose of 100 mSv for the first year after the Chernobyl accident (from 26 April 1986 till 26 April 1987), then 30 mSv for the second year and 25 mSv in each of 1988 and 1989 (IAC 1991). In all, till 1 January 1990 the dose of general public not exceeding 173 mSv was allowed from the radioactive fallout of the Chernobyl accident.

In order to limit internal exposure of the population, the temporary permissible levels (TPLs) of radionuclide content in food products and drinking water were elaborated in the USSR. Table 3.2 presents the TPLs for main food products (IAC 1991; Balonov 1993). The first TPL set approved by the USSR Ministry of Health on 6 May 1986 concerned the ^{131}I-activity concentrations as a dominating factor of human internal exposure in the early period of the accident, and was aimed at limitation of the thyroid dose of children to 300 mGy. The next TPL set adopted on 30 May 1986 concerned content of all beta emitters in food products caused by surface contamination, but was substantiated with primary attention to ecologically mobile and long-lived caesium radionuclides. The later TPL sets put in force since 1988 (TPL-88) and 1991 (TPL-91) concerned the sum of ^{134}Cs and ^{137}Cs activities. The TPL-91 for caesium radionuclides was supplemented by TPLs for ^{90}Sr.

Annual consumption by rural inhabitants of the usual food ration, all components of which contained caesium radionuclides at the level of TPL-86, would cause internal dose of less than 50 mSv, TPL-88 – less than 8 mSv, and TPL-91 – less than 5 mSv.

TABLE 3.2. TEMPORARY PERMISSIBLE LEVELS (TPL, Bq kg-1) OF RADIONUCLIDE CONTENT IN FOOD PRODUCTS AND DRINKING WATER ESTABLISHED IN THE USSR IN 1986–1991, AFTER THE CHERNOBYL ACCIDENT (IAEA 1991; BALONOV 1993)

TPL	4104-88	129-252	TPL-88	TPL-91	
Date of adoption	06.05.1986	30.05.1986	15.12.1987	22.01.1991	
Nuclide	^{131}I	β-emitters	^{134}Cs + ^{137}Cs	^{134}Cs + ^{137}Cs	^{90}Sr
Drinking water	3700	370	18.5	18.5	3.7
Milk	370–3700	370–3700	370	370	37
Dairy products	18500–74000	3700–18500	370–1850	370–1850	37–185
Meat and meat products	–	3700	1850-3000	740	–
Fish	37000	3700	1850	740	–
Eggs	–	37000	1850	740	–
Vegetables, fruits, potato, root-crops	–	3700	740	600	37
Bread, flour, cereals	-	370	370	370	37

TABLE 3.3. CURRENT ACTION LEVELS (Bq kg^{-1}) FOR CAESIUM RADIONUCLIDES IN FOOD PRODUCTS ESTABLISHED AFTER THE CHERNOBYL ACCIDENT

Country, International body	CAC	EU	Belarus	Russia	Ukraine
Year of adoption	1989	1986	1999	2001	1997
Milk	1000	370	100	100	100
Infant food			37	40–60	40
Dairy products		600	50–200	100–500	100
Meat and meat products			180–500	160	200
Fish			150	130	150
Eggs			–	80	6 Bq/egg
Vegetables, fruits, potato, root-crops			40–100	40–120	40–70
Bread, flour, cereals			40	40–60	20

Action levels for ^{131}I in foods established in some European countries in May 1986 varied in the range of 500 to 5000 Bq kg^{-1} among countries. Later on, the EU authorities established two values for caesium radionuclides in imported foods, one for milk and infant food and another for all other food products, see Table 3.3 (EC 1986; IAC 1991). Similar values were introduced in Nordic countries with an exception for wild foods (reindeer meat, game, freshwater fish, forest berries, fungi and nuts) that are important products for some local populations and especially for indigenous people. Thus, in the first month Sweden imposed action levels of 5 kBq kg^{-1} for ^{131}I and 10 kBq kg^{-1} for ^{137}Cs in imported food; for domestic foods the respective values were 2 and 1 kBq kg^{-1}. In the middle of May, action levels of 300 Bq kg^{-1} ^{137}Cs for all food and 2 kBq kg^{-1} for ^{131}I in milk and dairy products were introduced. For wild foods produced or consumed in the Nordic countries, the action levels varied between 1500 and 6000 Bq kg^{-1} in different countries and time periods.

Along with the standards for food products, the standards for agricultural raw materials, wood (see Section 3.3), herbs, and for beta contamination of different surfaces were introduced in the USSR (IAC 1991).

The general policy of the USSR and later on of the authorities in the separate republics was to reduce both the radiological criteria and TPLs along with natural improvement of radiological conditions due to radionuclide decay and penetration/fixation in soil. Gradual TPL reduction has been used as an instrument to force producers to apply technologies that decreased radionuclide content in products in order to limit associated human exposure. The TPLs were substantiated by expert weighting between intentions to reduce internal dose in populations and not to terminate profitable agricultural production and forestry in the controlled areas. Different reference levels for numerous groups of food products were established with the aim not to restrict consumption of any foods, unless the dose criterion might be exceeded.

At the end of 1991, the USSR had split into separate countries, among them Belarus, Russia and Ukraine, which had been strongly affected by the Chernobyl accident, and afterwards each country implemented its own policy of radiation protection of the public. Because of acceptance by ICRP in 1990 of the annual effective dose limit for the public in practice situations equal to 1 mSv, this level was considered by the authorities of the three countries as safe also in post-emergency conditions. Therefore, it is still used in national legislations as an intervention level of annual dose caused by Chernobyl fallout for introduction of countermeasures, including long-term remediation measures.