Environmental Health Criteria 25

SELECTED RADIONUCLIDES

TRITIUM
CARBON-14
KRYPTON-85
STRONTIUM-90
IODINE
CAESIUM-137
RADON
PLUTONIUM

World Health Organization

INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

ENVIRONMENTAL HEALTH CRITERIA 25

SELECTED RADIONUCLIDES

TRITIUM
CARBON-14
KRYPTON-85
STRONTIUM-90
IODINE
CAESIUM-137
RADON
PLUTONIUM

Published under the joint sponsorship of
the United Nations Environment Programme,
the International Labour Organisation,
and the World Health Organization

World Health Orgnization
Geneva, 1983

The International Programme on Chemical Safety (IPCS) is a joint venture of the United Nations Environment Programme, the International Labour Organisation, and the World Health Organization. The main objective of the IPCS is to carry out and disseminate evaluations of the effects of chemicals on human health and the quality of the environment. Supporting activities include the development of epidemiological, experimental laboratory, and risk-assessment methods that could produce internationally comparable results, and the development of manpower in the field of toxicology. Other activities carried out by the IPCS include the development of know-how for coping with chemical accidents, coordination of laboratory testing and epidemiological studies, and promotion of research on the mechanisms of the biological action of chemicals.

ISBN 92 4 154085 0

CONTENTS

PROTECTION 1982 EDITION"

NOTE TO READERS OF THE CRITERIA DOCUMENTS

While every effort has been made to present information in the criteria documents as accurately as possible without unduly delaying their publication, mistakes might have occurred and are likely to occur in the future. In the interest of all users of the environmental health criteria documents, readers are kindly requested to communicate any errors found to the Division of Environmental Health, World Health Organization, Geneva, Switzerland, in order that they may be included in corrigenda which will appear in subsequent volumes.

In addition, experts in any particular field dealt with in the criteria documents are kindly requested to make available to the WHO Secretariat any important published information that may have inadvertently been omitted and which may change the evaluation of health risks from exposure to the environmental agent under examination, so that the information may be considered in the event of updating and re-evaluation of the conclusions contained in the criteria documents.

ENVIRONMENTAL HEALTH CRITERIA FOR SELECTED RADIONUCLIDES

At the request of the United Nations Environment Programme (UNEP), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) prepared a paper on the Environmental Behaviour and Dosimetry of Radionuclides. In accordance with the UNEP proposal, the paper, which was prepared during the 27th - 29th sessions of the Committee and was completed and approved at the 30th session in 1981, is now being published in the WHO/UNEP Environmental Health Criteria series. The EHC document, which is entitled "Selected Radionuclides", comprises the integral report prepared and edited by UNSCEAR, together with an annex consisting of excerpts taken from "Basic Safety Standards for Radiation Protection 1982 Edition", Safety Series No 9, a document prepared jointly by IAEA/ILO/NEA(OECD)/WHO, and published by the International Atomic Energy Agency, to give guidance to the appropriate national authorities on the establishment of limits for radionuclides. The selected radionuclides discussed in the Environmental Health Criteria document are those of environmental importance for the general population and radiation workers.

Dr E. Komarov, Environmental Health Division, World Health Organization, was responsible for the final layout of the Environmental Health Criteria document.

The assistance of Dr B.G. Bennett (Monitoring and Assessment Research Centre, MARC) in the scientific editing of the Environmental Health Criteria document is gratefully acknowledged.

The contents of the 1982 UNSCEAR report to the General Assembly of the United Nations were taken into account during the preparation of the paper on the Environmental Behaviour and Dosimetry of Radionuclides, but the report was not quoted as it had not been issued at that time.

ENVIRONMENTAL BEHAVIOUR AND DOSIMETRY OF RADIONUCLIDES

1. PREFACE

1. The release of radioactive materials to the environment potentially exposes populations to ionizing radiation and increases

the risk of incurring deleterious health effects. The associations of released amounts to effects establish the health criteria for radionuclides, i.e., the quantitative relationships that would be required to establish release limits governing the management of radioactive materials used by man.

2. This report has been prepared by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) for the United Nations Environment Programme (UNEP) to provide background information in establishing such health criteria. In this report the more general considerations of environmental behaviour of several radionuclides are discussed, including sources, transport to man and dosimetry. The radionuclides discussed are those most frequently released from natural and man-made sources and the greatest contributors to population radiation exposure under normal circumstances.

3. The compilation of the relevant information is based largely on the detailed presentations and evaluations of the sources of ionizing radiation by UNSCEAR in its reports to the United Nations General Assembly. The reader is referred to these reports for general concepts and for assessments of the dose commitments to man from exposures to sources such as natural radioactivity, fallout from atmospheric nuclear testing, releases from nuclear power production, occupational and medical irradiations.

4. Further information to be considered in establishing health criteria for radionuclides is that on health effects of irradiations. The relationships between radiation dose and risks of health effects in man have recently been re-evaluated based on the available data. This information can be found in the 1977 report of UNSCEAR. Only a brief summary of the general aspects of radiation effects and of radiation protection considerations is presented here.

5. The establishment of release limits for radionuclides in particular situations cannot be accomplished without rather more detailed considerations of the local and regional environment and the special pathways of transfer to man. With this in mind, it is recognized that the material given here can only serve as background guidance.

6. The following scientists have contributed in the preparation of this report: Dr. W.J. Bair, Dr. D. Beninson, Dr. B.G. Bennett, Dr. A. Bouville, Dr. P. Patek, Dr. G. Silini and Dr. J.O. Snihs.

I. INTRODUCTION

7. Radionuclides are a special class of environmental substances. They are the unstable configurations of chemical elements which undergo radioactive decay, emitting radiation in the form of alpha or beta particles and x or gamma rays. The interaction of radiation with biological materials causes energy to be released to these materials which may result in a variety of harmful effects. Radiation is thus a potential hazard to man, although it may also be used in many beneficial ways, as in medical diagnosis and treatment, in industrial and consumer products and in the generation of electricity with nuclear reactors.

8. The realization of the harmful potential of ionizing radiation, which was dramatically brought to the attention of the public by the atomic bombing of Hiroshima and Nagasaki in 1945, was the cause of considerable attention that has been paid throughout the years to the effects of radiation. As a result of these studies, a great

deal is now known about radionuclide behaviour in the environment and in man and about the somatic and genetic consequences of irradiation. This information surpasses by far that relating to any other class of environmental pollutants.

9. Considerable experience has been gained in environmental radiation measurements, particularly in tracing the movement of fallout radionuclides produced in atmospheric testing of nuclear weapons. Much of this information has in turn contributed to the general knowledge of atmospheric and oceanic transport processes and of bio-geochemical cycles of elements. Extensive studies of radiation effects in animals and numerous epidemiological surveys of exposed population groups have by now been conducted. They have considerably enlarged our understanding of the biological effects of radiation on man and the environment, although uncertainties still remain, particularly regarding the basic mechanisms of action and the risk evaluations at low doses and dose rates [U1-U7].

10. A few definitions and general concepts should be introduced before the detailed presentation of radionuclide assessments. The basic unit of radioactivity is the becquerel (Bq), corresponding to one disintegration per second. The previously used unit was the curie (Ci), one Ci corresponding to 3.7 10^{10} Bq.

11. The basic measure of radiation interaction in irradiated materials is the absorbed dose (D). This quantity is also the basis of health risk estimates, under the assumption of a linear relationship between dose and risk. The absorbed dose is defined as the mean energy (joules) imparted to the irradiated material per unit mass (kg) at the point of interest. The unit of absorbed dose is ca11ed the gray (Gy) which corresponds to 1 J/kg. The unit of absorbed dose previously in use, the rad, is one hundred times smaller than the Gy.

12. Radiations of different types and energies have different effectiveness for producing effects, depending on the amount of energy transferred per unit length (LET) along the path of the charged particles. In order to quantify this differing effectiveness, use is made of a normalizing quantity called the quality factor (Q). For general purposes of radiological protection the assumed values of Q are: 1 for x and gamma rays and for electrons; 10 for neutrons and protons; 20 for alpha and multiply charged particles.

13. The product of the absorbed dose, D, and the quality factor, Q, is termed the dose equivalent (H). The unit of dose equivalent is the sievert (Sv). The previously used unit was the rem (1 rem =