Objectives and Design of Environmental Monitoring Programmes for Radioactive Contaminants

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OBJECTIVES AND DESIGN OF ENVIRONMENTAL MONITORING PROGRAMMES FOR RADIOACTIVE CONTAMINANTS

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FOREWORD

Environmental monitoring is a very important component of the verification system for demonstrating that the controls on the releases of radioactive substances to the environment under normal working conditions are functioning as intended. It is also used to provide timely information for decisions on any action that can be taken to protect the public in the event of a larger, accidental release.

There has been uncertainty in the past on the type and scope of the monitoring programmes required for different types of work involving the use of radioactive materials. This often stems from the lack of a clear understanding of the objectives of an effective monitoring programme. It can lead either to an inadequate system, which fails to give the necessary assurance, or to an overelaborate system, which is wasteful of resources in manpower and equipment.

For this reason the International Atomic Energy Agency and the World Health Organization convened a panel of experts which produced this manual of guidance for their Member States on the objectives and design of environmental monitoring programmes for radioactive contaminants.

In preparing the manual, attention was given to the recommendations of the International Commission on Radiological Protection, in particular to those connected with environmental monitoring, and to earlier publications of the IAEA and WHO on related topics.

Examples of environmental monitoring programmes and of the methods and techniques used have been provided by members of the panel for inclusion in the annexes to the manual.

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SECTION I. INTRODUCTION

101. This manual is intended to provide guidance on the objectives of environmental monitoring programmes related to the use of radiation sources and radioactive materials and the operation of nuclear facilities, on the development of adequate programmes and procedures for the types of installations and the populations and environments concerned, and on the interpretation of the results of the monitoring procedures in terms of the assessment of the possible radiation dose to man.

102. The guidance provided is intended primarily for those whose function it is to design and operate environmental monitoring programmes for use under normal operating conditions and in foreseeable types of emergency situations.

103. Consideration is given to the responsibilities and functions of operators of nuclear facilities and of competent authorities, including Government Departments, public health and other public authorities who have responsibilities [1] for protecting the public against any detrimental effects to health, and the environment against the effects of radiation and radioactive materials. The responsibilities of the operators and the competent authorities in this respect must be very clearly defined.

104. The guidance provided is of a general nature and is intended to clarify the basic principles involved in such a way that they can be applied effectively in particular circumstances.

105. Some information on the identification of critical pathways and population groups, the characteristics, standardization and intercalibration of instrumentation, and the evaluation of radiation dose is included in the Annexes, together with examples of monitoring programmes designed for specific installations.

106. While it is hoped that this guidance will be of use to Member States at all stages of development in the use of ionizing radiation, particular attention is given to the special needs of developing countries and those with little experience in these matters.

107. The requirements for environmental monitoring have been dealt with in outline in IAEA Safety Series No.1 – The Safe Handling of Radionuclides. The topic has also been dealt with in more detail in IAEA Safety Series No.16 – Manual of Environmental Monitoring in Normal Operations; IAEA Safety Series No.18 – Environmental Monitoring in Emergency Situations; and WHO Publications – The Environmental Radiation Surveillance Laboratory, and Routine Surveillance for Radionuclides in Air and Water. These publications may be considered as complementary documents to this manual.

108. The present manual unifies and brings up to date the principles and objectives of environmental monitoring for normal situations and emergency situations enunciated in these earlier publications. Useful reference can still be made to the technical material contained in the WHO publications and in the annexes to IAEA Safety Series Nos 16 and 18.

SECTION II. ASSESSMENT OF THE NEED FOR ENVIRONMENTAL MONITORING AND DEFINITION OF ITS OBJECTIVES

201. Environmental surveillance systems vary in size and complexity and should be related to the expected potential hazard. A competent authority will require a routine environmental monitoring programme when a potential release of activity or the expected radiation levels will result in one of the following:
   (a) A significant fraction of the dose limits to critical groups or the whole population recommended by the International Commission on Radiological Protection [2]
   (b) A significant fraction of that permitted by local regulations, where appropriate.

   The numerical values for these fractions should be fixed in the light of local conditions. Effluent monitoring, which is mandatory in any case, should provide sufficient information for the assessment of environmental levels where environmental monitoring is not required.

OBJECTIVES OF ENVIRONMENTAL SURVEYS FOR NORMAL SITUATIONS

202. The primary objectives of environmental surveys for normal situations are:
   (a) Assessment of the adequacy of controls on the release of radioactive materials to the environment
   (b) Assessment of the actual or potential exposure of man to radiation or to radioactive materials present in his environment or, as a minimum, the estimation of the probable upper limits of such exposure
   (c) Demonstration of compliance with the applicable regulations, environmental standards, and other operational limits
   (d) The possible detection of any long-term changes or trends in the environment resulting from the operation of the installations.

203. Additional benefits received from such environmental surveys may include:
   (a) An increase in knowledge concerning the correlation of levels of discharge and the environmental effect, thus

improving the basis for future predictions and for the estimation of maximum or other levels that might arise in an emergency

(b) The provision of data that may be used to provide the public with adequate information on environmental surveillance

(c) The maintenance of a capability that will go at least some way to providing a means for dealing with a foreseeable emergency situation

(d) The provision of data related to the behaviour of elements in the environment including the ecological, hydrological, geochemical and meteorological aspects of such behaviour.

OBJECTIVES OF EMERGENCY SURVEYS

204. The primary objectives of emergency surveys are:

(a) The rapid compilation of information, on a timely basis, on the magnitude and location of the possible hazards to the public for the purpose of defining the type and extent of any necessary countermeasures or other emergency procedures

(b) The assessment of any hazard from inhalation or external radiation to serve as a basis for the planning of immediate countermeasures

(c) The rapid determination of the possible contamination of foodstuffs, including milk and drinking water, as a basis for decisions on rejection or continued use

(d) The provision of data necessary to assess the radiation doses actually received by members of the public, taking into account any countermeasures that have been applied

(e) To provide information for the public regarding the emergency situation.

Another benefit to be obtained from such emergency surveys is:

(f) The collection of scientific information on the results of the emergency and on the behaviour of the released radioactive material in the environment. Such information may be useful in checking the adequacy of the monitoring and accident mitigation systems and to determine whether any changes are required in the routine monitoring programmes.

SECTION III. RESPONSIBILITIES FOR THE DESIGN AND IMPLEMENTATION OF ENVIRONMENTAL MONITORING PROGRAMMES

301. The delegation of responsibilities for the monitoring of radioactive sources and materials varies according to the administrative practices adopted by the country. However, in general, the responsibility for monitoring is shared by both the operator of the installation and the competent authorities.

302. There is no intention of defining in the following paragraphs the concept of legal responsibility, but only of outlining the functions that could be assumed by both the operator and the competent authorities. Effective implementation of these functions depends heavily on close co-operation between the two parties. The operator who is responsible for the facility should be duly authorized by the competent authority; the individual responsibilities of both the operator and the competent authorities should, however, be clearly defined by the national authorities [1].

THE OPERATOR

303. The functions of the operator usually are:
   (a) To prevent any unacceptable radiation or contamination hazard to the health of the public or damage to the environment resulting from the work performed within the installation and/or waste releases into the environment
   (b) To comply with the applicable regulations
   (c) To provide the means for dealing with the consequences, outside the installation, of radiation accidents that may occur within the installation, in agreement with the competent authorities.

304. To carry out properly these functions the operator will normally have to:
   (a) Perform all necessary pre-operational investigations to serve as a basis for effective environmental monitoring programmes
   (b) Design, and provide means for performing, adequate off-site environmental monitoring programmes for use during normal operation that will give assurance to the public

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authorities that the dose to members of the public remains below the allowable limit, and thus demonstrate to the competent authorities and to the public that no unacceptable hazard is created

(c) Design, and provide means for performing, emergency surveys outside the installation in accordance with the agreements established with the competent authorities

(d) Notify the competent authority, in accordance with agreed procedures, on such topics as the occurrence of incidents and accidents involving radiation or release of radioactive materials to the environment, and the results of monitoring.

THE COMPETENT AUTHORITIES

305. The designated competent authorities usually have the following functions:

(a) To ensure that the members of the public and the environment are adequately protected, by, inter alia, establishing and implementing appropriate regulations and monitoring programmes

(b) To demonstrate to the public that judgements regarding the safety of the public are based on valid information.

306. To carry out these functions the competent authorities should normally:

(a) Identify those man-made sources in the environment that may significantly contribute to the exposure of the public

(b) Design, and provide means for performing, adequate routine environmental monitoring programmes in order to:

- check the monitoring performed by the operators
- extend the operators' programmes to include in some cases the investigation of other selected pathways in order to determine whether the situation is adequately controlled
- confirm and satisfy public opinion that there are no unauthorized releases of radioactive wastes
- check the effects of release of wastes from the widespread use (for example, in medicine, agriculture and industry) in premises that cannot be considered nuclear facilities of comparatively small amounts of radioactive substances.

(c) Design and provide means for performing emergency surveys in order to:
- supplement, in accordance with established agreements, the emergency surveys performed by the operators of the affected installations,
- provide a basis for effective countermeasures in the case of accidents (for example, transport accidents) that do not generally come under the responsibility of an operator.

Some of these tasks may be performed by the operator or user under the guidance of the competent authority.

SECTION IV. THE DESIGN OF ADEQUATE MONITORING PROGRAMMES

BASIC FACTORS

401. Monitoring programmes may be oriented either to effluent monitoring, to environmental monitoring or to both. Effluent monitoring is source oriented. It permits the determination of releases of activity from particular plants or operations either singly or in combination, and is effective for the early detection and determination of accidental releases. The effluent monitoring data may also be used with additional information on appropriate pathways to estimate environmental levels of contamination.

Environmental monitoring enables the direct measurement of environmental levels of contamination, so excluding the uncertainties of assumptions involved in the estimations from effluent monitoring. However, in many cases, the environmental monitoring programme can only confirm that environmental levels resulting from emissions are below some level determined by the minimum detectable level of the measurements.

402. Where it has been decided, on the basis of the criteria described in the first paragraph of Section II, that environmental monitoring is required, the monitoring programme conducted in the immediate vicinity of an installation should be designed to determine whether or not the release of radioactive materials from the installations is being held within the limits prescribed by the applicable environmental standards, regulations and other operating limits. The programme should also be designed to achieve in the best possible manner the other objectives that have been defined in Section II.

403. In designing such programmes, consideration should first be given to monitoring the special nuclides, media and location that provide:

(a) A clear indication of the degree of compliance with applicable standards and regulations

(b) Valid data for use in estimating potential exposure of the public

(c) Early indication of any significant unplanned releases that may have occurred.

The environmental and effluent monitoring data would, in turn, contribute information which will be useful in the periodic reviewing of the reference levels, such as derived working limits referred to in para.406 of this section.

404. The identification of critical groups and critical pathways permits the development of the most effective and economical environmental monitoring programmes. The pre-operational investigation may not, however, offer sufficient data for proper identification of the critical group, and assumptions must therefore be made on the basis of general knowledge and the experience gained in other programmes. The tentative nature of the identifications made at this stage and the possibility of other population groups and environmental pathways being critical should be kept in mind. The results of environmental monitoring following the start of operation shall be used to confirm or amend the conclusions drawn on the basis of pre-operational data. Among others, any conclusions regarding the possible movement through the environment of radioactive elements and transfer rates from the medium to different matrices should be verified by measurement of the radioactive elements after the start of operations. Periodic review of the results of monitoring programmes is also highly desirable.

405. Pre-operational investigations necessary for estimating the dose from planned releases and for the establishment of limits and conditions of radioactive releases from an installation to the environment include the study of the following:

(a) The types and activities of nuclides that will be released, their physical and chemical forms, the method and route of such release and the rates of releases (minimum, average, and maximum)

(b) The movement of the relevant elements through environmental pathways together with their dilution or reconcentration, and seasonal variations of such movements

(c) Natural and artificial features of the environment that affect the movement of the elements such as geological, hydrological, meteorological conditions, vegetation and the presence of water reservoirs and harbours

(d) The utilization of the environment for agriculture, water and food supplies, industry and recreation

(e) The distribution of the population according to age and sex, and dietary, occupational, domestic and recreational habits

(f) The existing levels of natural and man-made radioactivity and their seasonal variations

(g) The identification of biological and other indicator matrices of radioactive contaminant concentrations

(h) The existing chemical pollutants, which may interfere with the radionuclides in their dispersion and pathways

(i) The assessment of expected mean doses to representative individual members of the public following the studies carried out under all the above points

(j) The tentative determination of groups of individual members of the public who appear to be homogeneous with respect to possible radiation doses from the releases.

406. On the basis of the assessment of mean doses to groups of individual members of the public, who appear to be homogeneous with respect to possible radiation dose from environmental releases, under normal conditions, the particular group likely to be the most exposed is chosen as the critical group of the population. The environmental pathways leading to the exposure of this critical group of the population represent the critical pathways of exposure, and deserve primary consideration in the environmental monitoring programme.

407. When the relations between radiation levels and radionuclide concentrations in various components of the environment and the estimates of dose to the critical group have been made, derived quantities such as the concentrations and the time integrals of concentration in food stuffs, air, water, etc. corresponding to acceptable doses can be adopted as derived working levels for the monitoring programmes.

408. For the evaluation of the consequences of unplanned releases there should be, in addition, an assessment of the likelihoods of various foreseeable types of accidents, the types and activities of nuclides that might be released, and the environmental pathways followed by them. Appropriate action levels based on the monitoring programme should be specified.

409. With respect to investigations of the relative contributions of releases from an installation to the total environmental radiation levels and concentrations, ICRP Publication No.7, 1965, states: "The inclusion of measurements of radioactivity in the programme of preoperational investigations has a number of advantages, but will seldom provide the best way of distinguishing between activity from the installation and that from other sources. The natural activity of most

environmental samples will vary seasonally and, to a lesser extent, from year to year; preoperational results can be extrapolated to later years only approximately. It is therefore better, wherever possible, to distinguish between the activity from the installation and the natural activity by specific analytical techniques ..."

ESSENTIAL FEATURES OF ADEQUATE PROGRAMMES

410. The pre-operational investigations should provide quantitative data for the derivation of working limits and action levels for routine and emergency environmental monitoring. This monitoring is carried out by the measurement and/or analysis of materials in the critical pathways; when appropriate, other materials serving as suitable indicator matrices can be chosen. In this connection, the considerations of para.403 must be borne in mind.

411. The planned monitoring programmes should be appropriate to the needs, that is to the type of the installations, the type of the environment in the vicinity of the installations, the nature and extent of human utilization of the environment and the types and quantities of radionuclides that are expected to be released so that unnecessary collection of samples and making of measurements will be avoided.

412. The planning and execution of any environmental programme are a multi-disciplinary effort. Therefore the monitoring teams should be composed of persons trained in the different appropriate disciplines. It is also often advantageous to have personnel individually trained in more than one speciality.

MONITORING OF EFFLUENTS ONLY

413. The detailed review of installation plans and the pre-operational investigations may indicate that the expected releases of radionuclides would be of such quantity and level that concentrations in the environment and the doses to man will be insignificant (see para.201). In such a case it may not be necessary to provide for an extensive routine environmental programme.

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