IAEA-TECDOC-282

DE MINIMIS CONCEPTS IN RADIOACTIVE WASTE DISPOSAL

Considerations in Defining de Minimis Quantities of Solid Radioactive Waste for Uncontrolled Disposal by Incineration and Landfill

REPORT OF THE ADVISORY GROUP MEETING
ON DEFINITION OF DE MINIMIS QUANTITIES FOR RELEASE OF
LOW-LEVEL SOLID RADIOACTIVE WASTE
INTO THE TERRESTRIAL ENVIRONMENT
ORGANIZED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
AND HELD IN
VIENNA, 7–17 SEPTEMBER 1981

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FOREWORD

There has long been a recognition that if every waste material that contains some radioactivity had to be treated and disposed of as radioactive waste, the quantity of such material would be impractical for society to deal with since all material contains its own natural radioisotopes as well as natural and anthropogenic fallout. Therefore, a need often arises for defining threshold levels of radioactivity below which the handling and disposal of such materials would not require any more special administrative control and precaution than disposing of municipal trash. The task of defining such threshold levels is a practical question of applying the basic radiological protection standards to a specific case.

Since certain publications and documents refer to these levels of radioactivity as "harmless, "innocuous", "exempt from notification", or "non radioactive", the IAEA's effort to unify this somewhat imprecise terminology resulted in introducing the expression "de minimis" originating from the Latin quotation "de minimis non curat praetor", i.e. the law is not concerned with trivialities.

In 1979, the Agency had already initiated considerations on De Minimis levels for radioactive waste in the marine field, for legislative reasons. Namely, the London Convention on the Prevention of Marine Pollution by Dumping of Wastes makes a clear legal distinction desirable between the low level radioactive waste suitable for being dumped at sea under certain conditions and a special permit, and very low-level waste which might be dumped outside these conditions under a general permit, like non-hazardous waste.

This first attempt being restricted to this specific field, the Agency decided to enlarge its approach on considering in turn the definition of de minimis quantities of waste that could be disposed of into the terrestrial environment. For this purpose, an Advisory Group Meeting was organized in September 1981 with the intent to define in sufficient detail the field of interest, to identify possible approaches that would enable the selection of an appropriate *de minimis* concept, and to give recommendations to those competent national authorities wishing to dispose of radioactive wastes by suggested routes for the implementation of this *de minimis* concept on a national level.

As a basis for the discussion a working paper was prepared at the Secretariat by Dr. Zdenek Dlouhy in order to collect relevant information. The Advisory Group met from 7 to 11 September 1981 at IAEA Headquarters in Vienna. The participants were from 13 countries: Argentina (1 participant), Australia (1 participant), Belgium (1 participant), Canada (1 participant), Czechoslovakia (1 participant), France (1 participant, 1 observer), Federal Republic of Germany (1 participant, 1 observer), India (1 participant), Italy (1 participant, 1 observer), Japan (1 participant), United Kingdom (1 participant, 1 observer), United States of America (1 participant), Union of Soviet Socialist Republics (1 observer). The following International Organizations participated: CEC, ICRP, OECD/NEA, UNEP and WHO. A list of participants is given at the end of the document. The meeting was chaired by Dr. Roger H. Clarke, Head of Nuclear Assessments, National Radiological Protection Board, UK.

During the session, participants had the opportunity to exchange their views with participants of another Advisory Group meeting being held at IAEA Headquarters to consider procedures for establishing limits for the release of radioactive materials into the environment, an activity within the Radiological Safety Programme of the Agency and of direct relevance to the work of the Group.

The document, the sole purpose of which is to give a comprehensive account of the discussion of the Advisory Group meeting, was revised and completed by a consultant (Dr. Zdenek Dlouhy) before being circulated to all Advisory Group participants. Comments were sent by Mrs. Chapuis and Messrs. Bhat, Clementi, Clarke, Coulon, Davy, Gonzales, Healy, Ilari, Kirchmann, and Windsor; the most important contributions were made by Mrs. Chapuis and Messrs. Coulon, Gonzales, Healy and Ilari, the latter having proposed new versions of important parts of different chapters.

Although this document contains imperfections, it constitutes a new step in the definition of a de minimis concept. In this light the Agency will reconsider the former approaches and state the appropriate ways for improving the de minimis considerations and their developments.

J. Molinari
Scientific Secretary

HISTORY

- Working Paper Draft 1 (Z. Dlouhy)
  81-02-20
- Working Paper Draft 2 (Z. Dlouhy)
  81-07-15
- Advisory Group Meeting
  81-09-7/11
- Revised Version 1 (Z. Dlouhy)
  81-09-25
- Revised Version 2 (Z. Dlouhy J. Molinari)
  Comments of R.H. Clarke incorporated
  81-11-25
- Final Draft 1 (J. Molinari)
  Comments of participants incorporated
  82-03-30
- Final Draft 2 (J. Molinari)
  Comments of R.H. Clarke incorporated
  82-07-19
- Final Document (J. Molinari)
  Comments of participants and R.H. Clarke incorporated
  82-11-31

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1. INTRODUCTION

There has long been a recognition that if every waste material that contains some radioactivity had to be treated and disposed of as radioactive waste, the quantity of such materials would be impractical for society to deal with, since all materials contain its own natural radioisotopes as well as natural and anthropogenic fallouts. During the selection of various disposal options for different categories of radioactive wastes, a need often arises for definition of threshold levels of radioactivity below which a waste material would not require any administrative control. Therefore, several attempts have been made to define such levels of activities in waste materials, below which it might be disposed of directly into the biosphere in a manner similar to municipal trash.

Since certain publications and documents refer to these levels of radioactivity as "harmless", "innocuous", "negligible", or "non-radioactive", the IAEA' s effort to unify this somewhat unprecise terminology resulted in using the term de minimis (*) levels of activity or quantities of radioactive materials. They are defined as such levels of activity or quantities of radioactive materials that are so small that one is prepared to lose further control over them. Such a decision is based on the fact that their disposal to the environment would cause an increment to the total radiological impact to the population and to the risk incurred by any single individual, that is both so small as to be considered acceptable by the competent authorities, and of no further concern from the regulatory viewpoint. This implies further, that materials having such properties may be disposed of without notification or without special permit in a manner similar to non-radioactive municipal wastes.

However, it should be pointed out that there is a conceptual and, to a certain extent, quantitative difference between de minimis quantities and those referred to as exempt from notification, registration, or licensing. These exempt quantities represent such specific sources of ionizing radiation that under certain conditions the competent national authority may exempt them from notification based on the assumption that

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(*) The exact meaning of the word de minimis originates from a Latin quotation "De minimis non curat pretor", i.e. the law is not concerned with trivialities.

these sources are handled in a certain specific manner and the health hazard is properly analysed and is deemed acceptable . On the other hand, de minimis quantities of radioactive materials should be so small that evaluation of the potential health hazard would not be warranted and thus, they might be disposed of into the environment .

It should be mentioned in this context that the recent IAEA document on de minimis quantities suitable for dumping at sea under general permit [1] does not represent an exact analogy to this document. As stated in the London Dumping Convention, the IAEA has the responsibility to issue definitions, recommendations, and guidelines for those countries wishing to dispose of radioactive wastes into the sea. As a matter of fact, the Convention distinguishes three main categories of wastes:

- wastes prohibited from being dumped,
- wastes that may be dumped under special permit, and
- wastes below de minimis quantities that may be dumped under a general permit.

Apart from this, a definition of non-radioactive materials was proposed in this IAEA document as follows:

"Materials should be considered non-radioactive for the purposes of the London Dumping Convention, if (a) their content of radionuclides is not artificially enhanced relative to the normal levels of those radionuclides appropriate for that type of substance, (b) they are not potential sources of naturally occuring radionuclides for commercial and other purposes, and (c) they are not enriched in natural or artificial radioisotopes as defined under (b)."

However, it is important to emphasize that for the terrestrial environment, the regulation is largely a national problem and not international,(*) as the marine one is.

At present there are numerous exempt quantities in various Member States, based on the IAEA Safety Standards(1967)(**) [2]. Besides,

(*) except in a few cases, such as the Antarctic.

(**) A new edition of the IAEA Basic Safety Standards/1981/ has been completed recently in which exempt quantities are defined in light of a new approach recommended by the ICRP in its Publication No. 26/1977/ [3]. These recommendations can be briefly summarized as follows:
(a) No practice shall be adopted unless its introduction produces a positive benefit;

there are some countries that already practise disposal to the terrestrial environment and may not, currently, refer to this as de minimis. On the other hand, in some countries certain de minimis concepts are envisaged only to be of use to applicants intending to dispose of certain radioactive materials without further regulatory control, as well as to provide guidelines to regulatory bodies when considering the appropriateness of such disposal option.

In one Member State principles are under review for the definition of a de minimis waste concentration level for some natural radionuclides. As it was expected, resulting figures were comparable with radionuclide concentrations occurring naturally in the environment. In another country regulations are under development with the intent of establishing an interface level between waste categories, and below which a waste material could be disposed of in a manner similar to non-radioactive trash.

In any case, in spite of limited information available on the subject it may be concluded that there is a general consensus of experts from various Member States on how the de minimis levels of radioactive wastes may be defined. For those countries wishing to dispose of wastes to the terrestrial environment using a de minimis concept, a procedure is recommended in Section 3 of this document.

In the first step of the suggested procedure, consideration is given to the wastes that can be disposed of into the terrestrial environment under the de minimis concept as well as to possible technique(s) by which these wastes can be introduced into the environment. These aspects are discussed in Section 4.

In the second step a decision has to be taken on what the dose corresponding to the minimis concept should be. Such a dose, later on so

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(**) cont.

(b) All exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account; and

(c) The dose equivalent to individuals shall not exceed the limits recommended for the appropriate circumstances by the Commission.

These guiding principles have become known as justification, optimization and compliance with dose limits respectively.

called "de minimis level of dose"(1) or "de minimis dose" is related to both individuals and the population as a whole. Some approaches may be used, such as those based upon the definition of an insignificant level of risk (or of a sufficiently small fraction of the average natural background radiation) and of an insignificant level of detriment. These approaches are discussed in Section 5 of this document together with some considerations on the role of individual and collective dose commitments in selection of de minimis doses.

As a following step, a selection of appropriate dosimetric models should be examined which would be realistic in terms of potential effects to man taking into account different scenarios that may be developed and possible pathways of radionuclides to man. Considerations regarding these topics are contained in Section 6 of this document.

2. SCOPE OF THE DOCUMENT

This document deals with recommendations addressed to those national authorities wishing to dispose of low level radioactive waste into the terrestrial environment, on how de minimis levels or quantities can be derived.

It is not the intention of this document to deal with gaseous and liquid discharges of radioactive effluents into the environment or with licensed releases from different nuclear facilities. Also, disposal of radioactive wastes from the uranium industry - above all from mining and milling - are not covered here, since they should probably be subject to special regulations. The only radioactive materials covered here are

(1) The term "de minimis level of dose" or "de minimis dose" is here improperly used on grounds of simplification. The attention of the reader is drawn to the fact that the use of this expression in the remainder of the document in no way calls into question the principles laid down by ICRP according to which there is a linear dose-response relationship without threshold, and according to which, for the purpose of calculating health detriment, there cannot be a dose cut-off in the integration of collective dose.
The concepts developed in this document in no way contradict the linear-no-threshold hypothesis. The fact that some harm is postulated does not mean that de minimis level of harm cannot be defined. Moreover, there must be some situations where the individual and collective doses are so low as to be beneath regulatory concern. This is the de minimis concept.

declared solid radioactive wastes of very low activity which are controlled up to the point where deliberate control is lost, or wastes below a level that requires regulatory control.

As regards the disposal sites, these wastes are not intended to be disposed of in fully controlled disposal facilities, such as repositories located in shallow land, rock cavities, etc. On the other hand, it is considered that these materials should not be disposed of in any place, but should be handled like other municipal wastes. Among the different techniques available, only two are considered in this document, namely a sanitary landfill facility, and an urban incineration plant.

3. RECOMMENDED PROCEDURE

It is important to recognise that the implementation of the *de minimis* concept, in order to be practically applicable, will require the establishment of a procedure for waste screening and disposal below a *de minimis* level, which would result in a very simple and straightforward guidance to the potential users. This guidance can be expressed in terms of appropriate units (quantities and/or concentrations) of radioactive materials in the wastes, and each individual user would only be requested to apply this numerical guidance to his specific situation.

A suggested step-by-step procedure that may be followed at the national level is outlined in the following:

(1) Competent national authorities should identify, for each practice resulting in the production of radioactive wastes, possible waste management scenarios liable to an application of the *de minimis* concept, including source terms, composition of waste streams, mode of disposal and typical disposal site features. Recommendations for the definition of these scenarios are dealt with in section 4 of this document.

(2) Competent national authorities should establish dose levels from which *de minimis* quantities and/or concentrations can be derived, later on so called "*de minimis* levels of dose", taking into account all practices resulting in the production of radioactive waste in a given region (e.g. nuclear fuel cycle, applications of radionuclides in various fields of human activities, such as medicine, industry, agriculture).

Considerations on this subject are contained in Section 5 of this document.

(3) Competent national authorities should establish for each scenario defined in (1) a typical realistic environmental and dosimetric model, including typical population features, environmental pathways, and dose assessments (individual and collective).

(4) From this, competent national authorities can derive standard de minimis activity amounts and/or concentrations corresponding to the so called "de minimis levels of dose", or "de minimis dose", for each type of waste in each scenario, and referred to a single typical user.

(5) After a set of de minimis activity amounts and/or concentrations has been established by the competent national authorities for the various practices, scenarios and types of waste considered, each user can apply to his specific situation the appropriate de minimis values.

It is to be noted that the de minimis levels of activity or concentration could be affected by the relative weight that the authority attributes to various practices resulting in the production of other de minimis wastes in the region.

Moreover, the selection of de minimis levels in terms of activity amounts (disposal rates) or of activity concentrations should be based on the features of the scenarios and models considered. In particular, this choice could be affected by the relative importance that the authority intend to attribute to the individual risk and the collective detriment in the overall assessments mentioned above.

4. RADIOACTIVE WASTE AND DISPOSAL TECHNIQUES UNDER A "DE MINIMIS" CONCEPT

4.1 General

The principal objective for the disposal of insignificantly contaminated radioactive wastes under a de minimis concept is to demonstrate that these wastes may be disposed of in a manner identical to municipal non-radioactive wastes and that no further actions resulting from the radioactive nature of the wastes are necessary. In this way, the disposal of locally arising de minimis wastes can take place in a local environment in an effective manner and at a minimum cost.

To achieve this objective, it is necessary to examine the sources of such wastes and the possible disposal techniques that exist for similar non-contaminated wastes. Decision on whether any particular type of waste should be either included or excluded from de minimis considerations is primarily the responsibility of competent national authorities, since only they are able to establish the corresponding levels of dose and demonstrate that any effects resulting from this type of disposal are within the so called "de minimis levels of doses". However, some recommendations on types of wastes suitable for this practice together with description of the two most common disposal techniques that may be considered by national authorities are presented in this section.

4.2 Types of de minimis wastes

For wastes related to nuclear activities, the types of wastes that national authorities may consider under the de minimis concept could arise from many categories, notably

- combustible solid wastes having very low concentrations of a wide range of radioisotopes of various half-lives,
- combustible solid wastes contaminated with β / γ emitters of low activity or half lives of a few months or less,
- slightly contaminated liquid wastes accompanying solid wastes, e.g. organic solvents, that become mobilised during the disposal process, e.g. incineration,
- non-combustible solid wastes in which the contained radioactivity is characterised by low leachability, or a short half-life, or low radiotoxicity, or a combination of these factors.

These categories of wastes arise in industries using or manufacturing radioisotopes, in hospitals with radiopharmaceutical and nuclear medicine departments, in universities and research centres, and from all components of the nuclear fuel cycles.

These wastes may have diverse forms ranging from disposable syringes, animal carcasses, contaminated hardware through to large volumes of soil or concrete arising from land reclamation clearance and decommissioning of a nuclear plant.

Certain industrial processes, for example some metal smelters and fossil-fired generating plants that are clearly not part of the nuclear industry, produce wastes that contain radioactivity because of naturally occurring levels of uranium and/or thorium. The concepts and methodology developed in this document could be applied in considerations on the disposal of these wastes. However, because of the different socio-economic and other factors involved, the numerical values developed for these cases from the general concept may be different from those developed for the nuclear industry.
Broadly speaking, any waste and radioactive materials that meet the test of the procedures outlined in this document is a de minimis waste.

4.3 De minimis disposal techniques

For the purposes of disposal of wastes below the de minimis levels, the two main techniques used for conventional non-radioactive wastes are taken into consideration in this report; these are the disposal in a sanitary landfill facility, and the combustion in an incineration plant followed by further disposal of resulting ash. These two methods are in common use the world over, and normally the producer of some waste categories does not necessarily know whether his waste is going to a landfill facility, or to a municipal incinerator. Therefore, it is necessary for the competent national authorities to take into account, where relevant, both methods of waste disposal, and to select the more critical values in the assessment.

4.3.1 Sanitary landfill facility

Sanitary landfill facilities are frequently sited within or close to residential developments on areas of land that contain natural depressions or excavations which frequently intercept the water table. The soil/rock strata under the dumped waste varies considerably from site to site. The two extreme cases for radiological purposes are those involving carbonate terraces and reclaimed mangrove swamps.[1] The leachate generated within landfill dumps attacks carbonate rock leading to solution enlarged joints and fractures ranging in size from cracks to

(1) Not infrequently, the site selected for a landfill operation forms part of a reclaimation plan for mangrove swamps. In these cases, not only is the fresh water table intercepted, but there is also a tidal saline wedge interaction with the burial waste.

cavernous. Such altered bedrock provides direct routes for movement of raw leachate to the groundwater with little if any opportunity for improvement in leachate quality through sorption processes.

On the other hand, mangrove swamp sites are characterized by a thin organic soil layer over a much thicker porous sand strata. In this case, during each tidal cycle, there is unimpeded ingress of the leachate to the related estuary or near shore waters.

The refuse cells in land-filled operations usually become predominantly anaerobic shortly after emplacement. The decay of the emplaced waste produces methane, ammonia, hydrogen gas, alcohols, organic acids, and other partially oxidised organic species which exert a high biological oxygen demand. Rainwater infiltrating through these anaerobic zones may give rise to a leachate markedly different from any other liquid effluent arising from a nuclear facility and therefore, the solubility of the dumped radioactive materials in solutions of this type plays an important role in this context.

It should be noted that any radioactivity transported by the leachate will have a chemical nature quite unlike that experienced elsewhere in the nuclear fuel cycle. Thus, values of distribution coefficients and bioaccumulation factors that are generally accepted are inappropriate for dosimetric modelling of landfill operations.

The size, dumping intensity, close-down procedures, and near-term future land use of landfill sites are interrelated.
At one end of the spectrum, intensive sites have an operational life of some 5-10 years and may subsequently (or at least have the potential to) be used for commercial methane production. The reuse of these sites is frequently for active or passive recreation, with local building codes preventing the use for residential development until their stability can be guaranteed after approximately 20 years. There is also a possibility of a site being used as a source of waste derived fuels.
The much larger sites, which tend to be geographically more remote from suburbia, usually have many operating faces, and the rehabilitation of the dumped areas is progressive. There is usually a number of development options when such sites have been reclaimed. However, it is not uncommon for them to be the subject to a "green belt" planning restricion.

4.3.2 Incineration plant

The incineration of municipal wastes and of hospital and laboratory wastes has been developed to effectively sterilize and render harmless offensive wastes and to reduce the volume of wastes for landfill disposal. This disposal route requires the effective control of both the loading methods and the treatment of combustion products. Any de minimis radioactive wastes which are disposed of by such an established route, would normally represent a very small percentage of the overall waste stream.

Incineration requires effective combustion. Secondary fuel supplies are normally required to start the process and to maintain combustion temperatures of at least 800°C. Even when good combustion conditions are available, the combustion products require treatment in order to remove fly ash and if necessary, modify the chemical nature of the gases.

The factors to be considered in the de minimis disposal of radioactive waste by these methods are:

i) possible reclamation of wastes during initial sorting before incineration;

ii) radiation doses to operators of loading waste and handling ash;

iii) possible concentration of radioactive materials in the plant itself and in the ash or fly ash, and implications for maintenance staff and subsequent uses of the ash;

iv) effects of gaseous discharges on the critical population near the incinerator - perhaps within 3 km.

5. SELECTION OF DE MINIMIS DOSES

5.1 General

The selection of de minimis quantities of radioactive materials for disposal into terrestrial environment implies a decision on a negligible radiological impact in relation to both the disposal contribution to the radiation risk incurred by any exposed individual and the overall radiation harm incurred by the population as a whole from the disposal. The individual radiation risk is approximately measured in terms of the effective dose equivalent (herein after called dose) incurred by the exposed individuals. On the other hand, the radiation harm from the disposal can be assessed in terms of the detriment(*) arising from it, i.e in terms of collective effective dose equivalent commitment (herein after called collective dose commitment). It follows therefore, that the establishment of negligible - de minimis - levels of individual dose is a prior step to be taken before deciding on de minimis quantities of radioactive materials. However, this may not be a sufficient consideration since many negligible individual doses can result in a "not insignificant" collective dose. Therefore, as a following step, assessments regarding collective doses may need to be made. The following paragraphs present a discussion on the selection of the de minimis levels of doses.

In the first step, a decision needs to be taken on what is a de minimis individual dose arising from the disposal of de minimis levels of radioactive wastes and on what would be acceptable to the individuals involved. It is felt that the decision upon such a level of exposure should be taken by competent national authorities. Several approaches are available that are mentioned in the following text (see section 5.2). One approach deals with figures of acceptable risks that may result from exposures due to disposed wastes, another is based on derivation of a figure from standard deviation of natural background fluctuations over a given region. Consideration is also given to multiple sources as well as future doses from wastes of very low activity but containing long-lived nuclides. The approaches for selecting a de minimis level of collective doses are discussed in the last paragraphs (see section 5.3).

5.2 De minimis individual dose

It is generally agreed that the fatal risk associated with radiation exposure may be of the order of $10^{-2} Sv^{-1}$. On the basis of acceptable levels of risks, annual individual dose limits of 50 mSv for workers and of 5 msv and 1 mSv for members of the public have been established in the IAEA Basic Safety Standards. From these figures, a further low level of radiation exposure can be derived that may be considered trivial since

(*) The detriment is a quantity introduced by ICRP to determine the whole damage to man that can appear after an exposure to radiation. It includes both the stochastic and non-stochastic effects to the exposed individuals as well as stochastic effects in later generations. (IAEA, Basic Safety Standards, No.9, Revision January 1982, Annex 4, paragraphs 114-115).

the associated health risk is small in comparison with other individual risks accepted by society. Voluntary risks accepted by individuals in the society are typically in the range of 10^{-3}-10^{-5} yr^{-1}. Further lower levels of risk in the range 10^{-6}-10^{-7} yr^{-1} are generally considered negligible even if the risks are involuntary. Because of the public's concern with, and lack of knowledge of radiation and its effects, it is felt that the lower value of 10^{-7} yr^{-1} should be considered to assure that the involuntary individual health risk associated with this particular practice remains negligible. This in turn, translates to an individual dose of the order of 10 μSv yr^{-1}. This dose level applies to the critical group which is defined as a group of members of the public whose exposure is reasonably homogeneous and is typical of individuals receiving the highest dose.

An alternative approach to establishing de minimis levels of individual dose, for the purpose of disposing of de minimis quantities of waste materials to terrestrial environment, is to make reference to natural background radiation. The rationale for this approach lies in the knowledge that mankind has always been exposed to low doses of natural radiation, of the order of 1 mSv per year. If the individual dose arising from the disposal of solid wastes to the environment is sufficiently small in comparison with any harm caused by natural radiation background, then the associated increment of risk should be acceptable for the affected individuals. Since the individual impact of such a disposal practice is likely to be localized, an insignificant incremental individual dose is considered to be one that represents a fraction of the standard deviation of the natural background in the region of disposal. A de minimis individual dose derived in this manner will likely to be comparable with a de minimis individual dose derived on the basis of IAEA Basic Safety Standards individual dose limits and acceptable levels of risks.

Either of the processes described above would lead to annual individual doses in the order of 10 μSv as a maximum level for defining de minimis quantities of radioactive materials.

On the other hand, if the waste management scenario to which a given de minimis dose level refers includes several waste streams coming from different sources, the total dose to the critical group identified in this scenario will be the sum of contributions due to the various sources and waste streams. This sum should not exceed the de minimis dose previously defined.

Furthermore, the relative importance of one or the other waste source and stream with respect to the definition of the overall de minimis dose, may depend on the size of the population groups involved, that is on the collective dose commitment due to each source and stream of de minimis waste.

Another important factor to be taken into account in the application of the de minimis concept is the duration of the practice and the possible build up of individual doses. It should be recognized that the disposal of the de minimis quantities may give rise to individual doses that will be received in the future. This should be considered to ensure that present or future de minimis disposals would not be liable to result in an undue combined exposure of any individual.

All the above factors should be considered in defining the overall de minimis level of dose. This may take the form of a weighted sum of de minimis doses referred to the individual waste sources and streams composing the scenario considered; the weighting factors of this sum should be established to take into account the concerns expressed in the previous paragraph.

5.3 De minimis collective dose

The collective dose commitment is defined to include all doses incurred by all persons receiving a non zero dose from the disposal, both at present, and in the future. This assessment leads to a full double integration both over space and time of the predicted individual dose spectrum. In many cases of land disposal, however, the significant part of the integration can be in practice limited to the relevant population around the disposal area and to the short time related to the usually short lived radionuclides involved, making the assessment very much simpler[1].

One of the approaches to establishing a de minimis level in terms of collective dose commitment, is that of selecting the level below which the optimisation of radiation protection (in the waste management and control procedures) as required by the Basic Safety Standard system of dose limitation, is not further warranted; that is, the cost and the effort involved in treating and/or containing the waste, even if very small, are both more than the corresponding reduction of radiation detriment. This can be the case in a situation which involves such a low collective dose commitment that there is no justification for spending any more efforts on reduction of detriment. The determination of the value of the above mentioned de minimis level of collective dose commitment could be performed by means of an optimisation assessment between costs of waste treatment and corresponding detriment. However, the large variety of practices producing radioactive wastes and of the associated waste management and control operations may make the quantification of costs and detriments and the consequent optimisation process very difficult, especially on the scale of a whole country. In addition, if de minimis levels of activity or concentration are sufficiently low, the disposal of wastes with activities or concentrations lower than these levels may result in a collective dose commitment which is very small. In this case, even the mere effort spent in the optimisation process to assess the de minimis level of collective dose commitment could not be warranted.

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(1) The above reported considerations may be expressed in mathematical terms by the following equation:

$$\sum^{n} W_i \; D_i \leqslant \text{"de minimis" level of individual dose}$$

where:

Di = individual effective dose equivalent given to a certain critical group following a defined disposal practice of a defined type of waste. The appropriate environmental model should be applied to evaluate Di.

Wi = weight factor to be given to an i defined scenario of waste disposal, which will depend on the nature and type physical half-live, physico-chemical form) of the radioactive material and the nature and the type of disposal, and may involve considerations on the nature and size of the population exposed. Each Wi is such that $\sum W_i = 1$.

i = index identifying any of n defined scenario of waste disposal.

Therefore, decisions about alternative values of the de minimis level of collective dose commitment may sometimes need to be largely qualitative and intuitive, with a substantial content of value judgement. In any event, quantitative values for the de minimis level can be assessed approximately or in ranges, and this may still be deemed as satisfactory by regulatory authorities for practical purposes.

One possible approach of applying an intuitive optimisation process to the establishment of de minimis level, or levels of collective dose commitment can be to determine such level(s) as an appropriately small fraction of the total collective dose commitment due to the practice, or practices, which produce the wastes to be disposed of in an unrestricted way under the de minimis concept. This fraction can be established with reference to the whole of practices in a given country, giving therefore rise to a single value of the de minimis level of collective dose; however, regulatory authorities may deem it more appropriate to establish different de minimis levels referred to different types of practices, such as nuclear power, industry, medical application, etc.

6. MODEL SELECTION

The processes that govern the behaviour of radioactive materials disposed of in the environment are influenced by the characteristics of different compartments of the environment on the one hand, and by nature, type and properties of disposed radioactive materials on the other hand. The potential of man's exposure to these radioactive materials depends also on a number of other factors, among the most important of these factors are the utilization of different compartments for various purposes, and the distribution and habits of the population in the environs.

Major pathways between radioactive materials disposed to the terrestrial environment and man can be described in a simplified manner as shown in Fig. 1.

In order to apply the general procedure suggested in section 3 for the definition of de minimis levels, it is necessary to make use of generic models and waste management scenarios applied to the various practices producing potentially de minimis wastes in a given region.

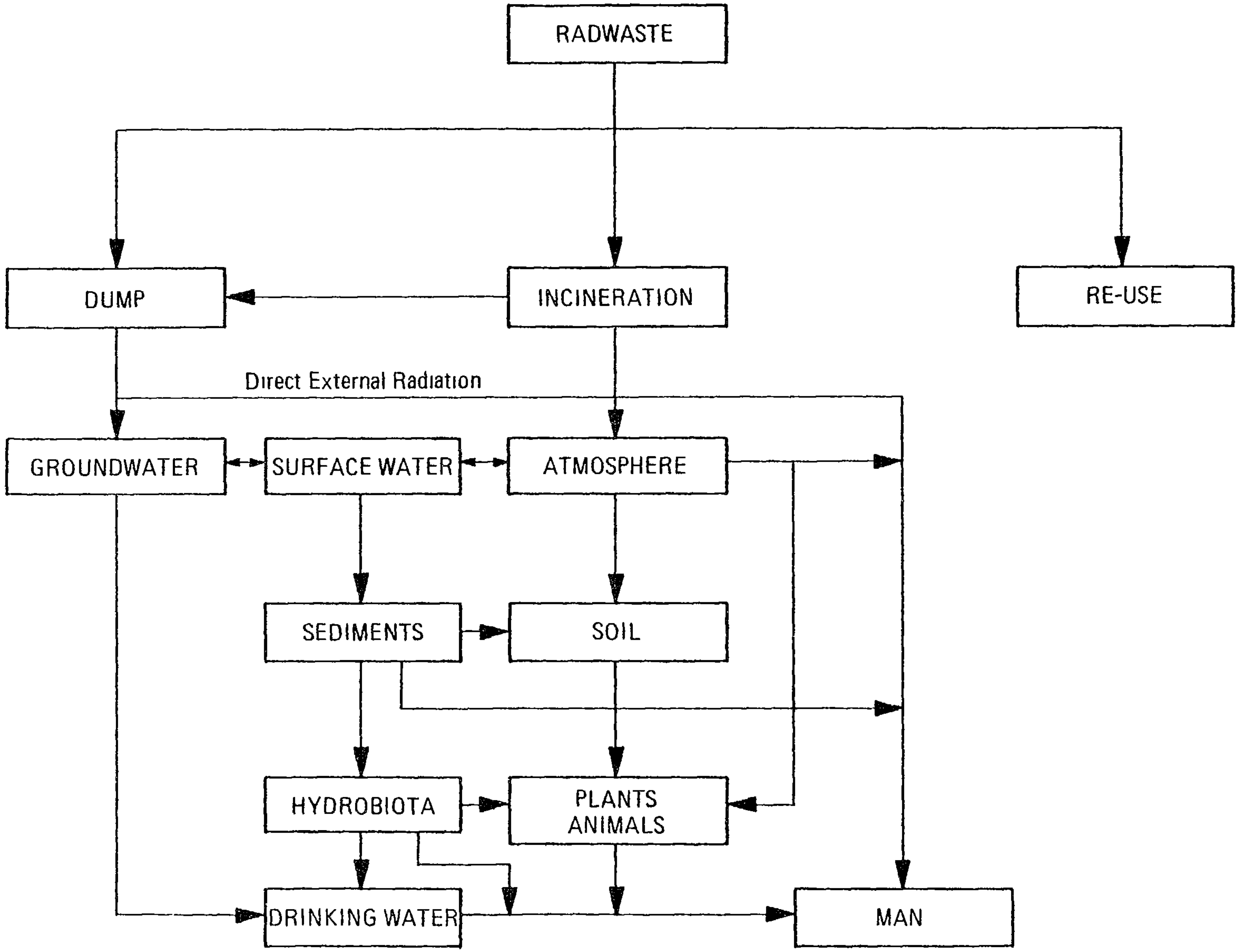

Fig. 1. Simplified pathways between radioactive wastes disposed of into the terrestrial environment and man.

For each waste management scenario established by the competent authority, a mathematical generic model has to be selected to provide estimates of quantities of wastes considered for dispoal that would correspond to de minimis levels of dose. Such a model should allow the calculation of doses received by the average person of a critical group exposed to the radiation from the radioactive wastes disposed of into the terrestrial environment. This model can be relatively simple, where only one pathway is significantly predominant. However, as a rule, more complex models are usually needed that would cover several different pathways through terrestrial and aquatic food chains as well as atmospheric dispersion considerations and direct irradiation of man from disposed de minimis wastes. The input data and the features of the model should take in due account the influence of the waste nature and composition, the disposal techniques, as well as the features of the disposal sites. In this respect, the model should be as realistic as possible. However, if adequate information is not available, particularly due to the complexity of a typical terrestrial environment and the difficulty of characterising the composition of wastes, conservative assumptions should be adopted in the application of the model.

These difficulties are enhanced by the fact that the models to be developed for the derivation of de minimis quantitites are generic, and this will inevitably introduce a large degree of approximation in the quantitative assessments involved. However, considering the negligible level of risks and detriments involved, this approximation may be deemed as acceptable, especially if balanced against the simplicity of the resulting arrangements for the screening and disposal of de minimis wastes. In particular, it is likely that, for each waste source and disposal stream, a "standard mixture" of radionuclides can be established which can be used in the calculations. The corresponding data can be used by a trial and error method to come to some values of activity amount or concentration which can be regarded as de minimis.

In the application of the model it has to be checked whether the de minimis quantities or concentrations derived by this method would not lead to undue exposure of the personnel on the landfill facility or at the incineration plant.

For both suggested disposal routes there are a number of applicable models in the literature. A recent IAEA publication dealing with generic models and parameters for assessing the environmental transfer [4] (1981) contains sufficient information on various aspects of radionuclide transport through terrestrial and aquatic food chains, and includes practically all major pathways by which a disposed de minimis waste can reach man. Also, the information given in the ICRP Publications 30 [5] can be used for the dose calculations(*).

Another basis for selection of an appropriate model may be an IAEA document at present under preparation dealing with principles and examples of safety analyses for radioactive waste repositories in shallow ground [6]. Several models for prediction of consequences of particular release scenarios through calculations of the transport of radionuclides in the environment are described therein in sufficient manner to be applicable also to landfill operations.

As regards incineration plants, models for atmospheric dispersion are available in great number. Examples may be taken from various IAEA documents dealing with releases of gaseous effluents into the environment [7, 8].

The pathways and process perturbations indicated in Appendices I-II are intended as examples of items for inclusion in a comprehensive check list that should be prepared by competent authorities or by operators of relevant facilities.

7. CONCLUSIONS AND RECOMMENDATIONS

1. Any disposal of radioactive substances to the environment, in whatever form it is carried out, should be governed by the principle that the radiological protection of the public has been "optimised", the term "optimised" being based on considerations of relative risks and economic and social constraints. The concept of "de minimis" levels of activity for disposal in the terrestrial environment is

(*) It should be noted that data given in this publication have been defined within the framework of basic recommendations of ICRP-Publication 26 restricted to protection of workers. Their extension to a larger public has not yet been undertaken.

such that it ensures that protection has been optimised without the need to undertake complex evaluations or to implement administrative and technical control procedures.

2. The AG participants have agreed that there is a need for definition of de minimis quantities of declared solid radioactive wastes that would allow their disposal in the terrestrial environment without further consideration of the associated radiological harm.

3. The basis for establishing these de minimis quantities is consideration of de minimis levels of both individual radiation risk and radiation detriment. Two different approaches have been mentioned: one deals with figure of acceptable risks and the other is based on comparison with regional background fluctuations. If the disposal of wastes to the terrestrial enviroment leads to individual doses sufficiently low and the associated collective dose commitments is sufficiently small as to not warrant further consideration, there may be no need of any special disposal precaution from the radiological point of view.

4. The actual levels of both individual dose and eventually collective dose commitment which are set for the de minimis level must be the responsibility of the competent authority in any country where a decision was accepted to dispose of radioactive waste by this route. This report has discussed the considerations which need to be taken into account by those competent authorities and has given, as an indicative value only, the order of magnitudes which might be expected.

5. It is expected that from the de minimis doses, both individual and collective, competent national authorities wishing to apply this disposal option in the future will derive de minimis quantities of wastes which can be disposed of into the terrestrial environment.

6. The AG could only suggest a method of determining de minimis quantities. Suitable procedures for calculating appropriate concentrations are still to be established. In order to promote this, the Agency should sponsor the establishment of dosimetric models in detail for the calculation of individual and collective dose in the vicinity of a landfill and an incinerator plant. This

includes the evaluation of individual data on the behaviour of the elements and their compounds within a landfill and an incinerator and the transfer of these elements to the environment and man. The work on dosimetric models of similar kind e.g. for the shallow land burial of radioactive waste should be taken into account. It is recommended that for some well defined examples of landfills and incinerators, de minimis quantities be derived numerically. However, due to varying conditions from place to place, in some cases this may not be a sufficient consideration and therefore, some assessments of collective doses need to be done by those applying the principles.

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APPENDIX I

Perturbations To The Landfill Site Which Could Affect Release of Activity

(After Table II, p. 17 "Principles and examples of safety analysis for radioactive waste repositories in shallow ground)[6].

A. Human Activities

A.1 Design and operating factors

- water or wind action on waste during loading
- presence, or production through processes within the site, of chemicals which change properties of the leachate or soil, enhancing leaching and/or radionuclide migration
- drainage system obstruction
- improper waste emplacement
- top cover failure
- material diversion

A.2 Intrusion

- material salvage
- construction activities
- farming
- groundwater exploitation
- habitation

B. Natural Processes and Events

B.1 Biological intrusion: plants, animals

B.2 Faulting, seismicity

B.3 Fluid interactions: erosion, flooding, inundation, water table fluctuation, groundwater flow, seeping water.

B.4 Weathering: deterioration with time of landfill site integrity due to freezing/thawing, wetting/drying, and erosion.

C. Waste and Repository Processes

C.1 gas generation

C.2 structural deformation due to waste deterioration, waste and soil compaction

C.3 fire (during and after emplacement)

APPENDIX II

Pathways

Worker

1. External radiation from handling of wastes
2. Inhalation from resuspension during handling or moving of wastes
3. External radiation from unburied wastes and those close to the surface
4. Absorbtion through intact or broken skin
5. Inhalation from dust, gases and mist during a fire within a landfill.

Public

1. Ingestion of, or immersion in contaminated water:
   a) from contaminated aquifer
   b) from surface water contaminated from aquifer or direct run-off from landfill
   c) from discharge of treated leachate
2. Use of contaminated water from irrigation of crops and direct consumption by animals
3. Eating of contaminated aquatic biota from contaminated water
4. Direct exposure from or inhalation of gases released from the landfill and containing radioactive materials
5. Deposition of particles entrained with gases, on plants and soils leading to subsequent ingestion by animals and man, external radiation from and inhalation of sludge produced by the treatment.
6. Intrusion leading to:
   a) direct exposure to and inhalation by intruder
   b) removal of articles leading to inhalation, ingestion and direct exposure to the intruder and others
7. For long-lived materials, eventual removal of cover by erosion
   a) people living on site - contaminated food and inhalation by resuspension
   b) people off-site similar to those on site where material deposits plus exposure from transported sediments in stream.

APPENDIX III

Perturbations To Incinerator Operation Which Could Affect Release of Activity

Human Activities

- unintentional redirection of wastes intended for incineration
- incinerator operator errors or plant malfunction
- improper waste handling
- ash spills at incinerator, or during transport, or at disposal site

Incineration Processes

- concentration of certain contaminants on plant surfaces
- concentration of certain contaminants in ash in excess of derived landfill *de minimis* values
- blow back of contaminated dusts
- failure of combustion products processing stream
- incinerator temperature transients
- incinerator pathways to man

APPENDIX IV

List of Major Pathways Relative to an Incinerator Plant

Workers

1. Direct external exposure while handling waste or contaminated equipment
2. Inhalation of radioactive material from re-suspension from waste or contamination transferred to the building
3. External doses of resuspension during repairs or decommissioning of the incinerator
4. Contamination of workers from the wastes and subsequent transfer to other persons
5. Salvage of waste
6. Associated transport routes

Public

1. External exposure and inhalation from off gas plume
2. Deposition of particulates or vapours from off gas plume on plants and soil with subsequent movement to man through direct ingestion or via animal products
3. External dose from particles or vapours deposited on the ground
4. External radiation, body contamination, and inhalation of ash spilled in the facility and subsequently moved outside.

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