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CONSIDERATIONS CONCERNING "DE MINIMIS" QUANTITIES OF RADIOACTIVE WASTE SUITABLE FOR DUMPING AT SEA UNDER A GENERAL PERMIT

REPORT OF AN ADVISORY GROUP MEETING
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FOREWORD

The IAEA submitted to the Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) in October 1976 the provisional definition and recommendations concerning radioactive waste and matter unsuitable for dumping into the oceans. This was done in response to the request outlined in Annexes I and II of the Convention. It was subsequently accepted for implementation by the Contracting Parties of this Convention and the Agency has kept the definition and recommendations under continuing review. In 1978 the Agency submitted a significantly revised definition and recommendations to the Contracting Parties at the third Consultative Meeting, which was subsequently accepted for implementation at their fourth meeting.

The Agency has been requested by both the Contracting Parties and the IAEA Board of Governors to address closely related aspects of the definition and its recommendations and to produce guidelines for those countries wishing to dispose of radioactive wastes into the ocean. One of these areas relates to the concept of a de minimis level of radioactivity which could be dumped into the oceans under general permit regulations rather than under the more restrictive special permit.

For non-radioactive pollutants, the Convention applies terms such as "trace contaminants" and "insignificant amounts of substances" which are exempt from the provisions of the Convention. A similar need exists for radioactive pollutants especially as all material contains some radioactivity and it is clearly not the intention of the Convention to assume that every material should be treated as a potential radioactive pollutant.

Thus, there is a need to define a threshold level of radioactivity which can be considered sufficiently small that would be considered negligible for practical purposes.

CONTENTS

1. INTRODUCTION

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Dumping Convention)[(1)] distinguishes amongst three types of waste, e.g., those specified in Annex I to the Convention which are prohibited from being dumped, those specified in Annex II which require a special permit issued by the competent national authority and finally other wastes that can be dumped under a general permit. Both types of permits are subject to careful consideration of the factors set forth in Annex III.

Radioactive wastes are included under Annexes I and II. Paragraph 6 of Annex I to the Convention provides for the IAEA to define high-level radioactive wastes or other high-level radioactive matter as unsuitable for dumping at sea, and Section D of Annex II provides for the IAEA to make recommendations which the Contracting Parties to the Convention should take fully into account in issuing permits for the dumping at sea of radioactive wastes or other radioactive matter "not included in Annex I".

Consequently, the IAEA has defined high-level radioactive wastes or other high-level radioactive matter for purposes of the Convention and has made recommendations on the conditions under which special permits could be issued for the dumping of radioactive material falling outside of its definition. These definition and recommendations are under continuing review by the IAEA in light of technical developments and increased scientific knowledge regarding the effects of dumping radioactive waste into the deep sea.

Annex I of the London Dumping Convention specifically excludes certain waste types such as sewage sludges and dredged spoils which may contain, as trace contaminants, some of the prohibited substances, as in Annex I (i.e. organohalogens, mercury, cadmium, oils). If such contaminants are present in trace quantities or are rapidly rendered harmless, these wastes can be dumped under a special or general permit (trace quantities of radioactivity are, however, not exempted). Trace quantities were defined by an *ad hoc* scientific group on dumping to meet all the following conditions:-

(a) When they are present in otherwise acceptable wastes or other materials to which they have not been added for the purpose of being dumped.

(b) When they do not occur in such amounts that the dumping of the wastes or other materials could cause undesirable effects, especially the possibility of chronic or acute toxic effects on marine organisms or human health whether or not arising from their bioaccumulation in marine organisms and especially in food species.

(c) When they are present in such amounts that it is not practical to reduce their concentrations by technical means.

Test procedures for the definition of interpreting trace contaminants and harmlessness are then described which should be applied so as to provide evidence for the potential for acute or chronic toxic effects, the persistence of the material, inhibition of life processes and bioaccumulation under the proposed disposal conditions. Test procedures are not required for sewage sludge or dredge spoils if chemical characterization of the material and knowledge of the receiving area allows an assessment of the environmental impact.

Annex II of the London Dumping Convention specifies a number of substances (i.e. As, Pb, Cu, Zn, etc.) for which a special permit for dumping will have to be issued if significant amounts of the substances are present in otherwise acceptable waste. (Radioactivity is not included among the substances to which the term significant amounts apply.) The *ad hoc* scientific group proposed an interim definition in which significant amounts are defined as quantities of the substances in excess of 0.1% by weight of the waste to be dumped. This definition is continuously under review.

The IAEA's Revised Definition and Recommendations of 1978,[2] concerning radioactive wastes do not include terms such as "trace quantities", "significant amounts" or "harmlessness". It is stated that no material is totally devoid of radioactivity and that it is clearly not the intention of the Convention that every material should be treated as a potential radioactive pollutant and that it may therefore be necessary to define some *de minimis* level of specific activity below which a material will not be regarded as radioactive for the purposes of the Convention.

Following the principles proposed by the ICRP of balancing the costs and detriments of any practice involving radioactivity, there must be some level of radioactivity below which considerations other than those of the radioactivity itself are of overriding importance. For very low-level radioactive wastes, it is necessary to define a quantitative criterion which allows practical implementation of these principles within the terms of the London Dumping Convention.

It will be necessary therefore to consider how these requirements can be met by (i) defining material that can be regarded as non-radioactive for the purposes of the London Dumping Convention, (ii) defining a category of radioactivity in wastes whose content is sufficiently low (de minimis) that it can be dumped under a general permit if its other characteristics so permit. It is stressed that even if a material has been deemed to contain less than de minimis quantities of radioactive materials its suitability for dumping due to it's other constituents must still be carried out.

The question of defining such a de minimis level of radioactivity was considered by an Advisory Group meeting convened at the IAEA headquarters in Vienna from 2 to 6 July 1979.

2. DEFINITION OF NON-RADIOACTIVE MATERIAL

2.1 Although all materials are to some extent radioactive because of their content of primordial and cosmogenic nuclides and because of globally-distributed sources of man-made radioactivity from nuclear weapons, the definition of non-radioactive materials is intended to exempt many such materials from being classed as radioactive under the terms of the London Dumping Convention.

2.2 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, and (b) they are not potential sources of naturally occurring radionuclides for commercial or other purposes, and (c) they are not enriched in natural or artificial radioisotopes as defined under (b).

2.3 However, to clarify and to provide general guidance as to the interpretation, the definition in section 2.2 may be expected to apply to most materials which have not been in contact with, associated with, or intended for use in any anthropogenic nuclear process, excepting contamination by the global dissemination of debris from nuclear weapons testing or which have not been exposed to man-made nuclear radiations in such a way as to lead to the activation of stable elements in the original material. Excluded from this definition under the terms of 2.2(c) will be materials which, while otherwise fitting the criteria for non-radioactive substances. have by virtue of chemical treatments, not normally associated with the nuclear industry, acquired an enhanced level of naturally occurring radioisotopes.

2.4 All other materials not conforming to the definition in Section 2.2 should be considered radioactive for the purpose of implementing the terms of the London Dumping Convention.

2.5 If the radionuclide composition of the material to be dumped at sea is unknown, it would be prudent to consider such materials are radioactive for the purpose of implementing the terms of the London Dumping Convention.

3. THE DERIVATION OF A DE MINIMIS DOSE

3.1 The Basis for a De Minimis Level of Activity for General Permit Disposal

The current IAEA recommendations do not include procedures which provide for the granting of permits for disposal of waste containing radioactivity other than to the deep ocean. However, as all materials contain some activity, there is a practical need for a definition of wastes containing radioactivity which can be dumped under a general permit.

For all waste disposals, the general principles of radiation protection recommended by the International Commission on Radiological Protection (ICRP 26) should apply. These principles may be summarised as:

a) justification,

b) optimisation,

c) compliance with dose limits.

Radioactive waste releases to the environment should thus be controlled in accordance with the principles of the ICRP and of the IAEA recommendations as contained in Safety Series 45[3]. Consistent with these general principles, there may be a *de minimis* level of radioactivity in some wastes, which would make them suitable for disposal under a general permit. Various approaches could be used to develop a rationale for categorising radioactivity for the purposes of the London Dumping Convention.

One approach would be the specification of trivial quantities of radioactivity which would imply that at certain levels of radioactivity, decisions on the acceptability of a proposed disposal of waste at sea are dependent primarily on other properties of the material and only secondarily on its radioactive properties. This approach depends on the chemical and other characteristics of the wastes and it is concluded that the approach would not be useful for the development of general recommendations for radioactive materials to be dumped under a general permit.

Another approach is the consideration of the various levels of radiation protection afforded by alternative disposal methods. If the radiation protection offered by disposal at sea is greater than that of other alternatives, assuming all alternatives are practicable, then the ocean disposal alternative would be preferred. The problem here is again that this approach depends on the characteristics of the wastes and is therefore more amenable to the provision of guidance than the setting of specific numerical recommendations.

The more fundamental approach which has been adopted is to decide upon a *de minimis* level of dose which can then be used as a basis to establish levels of activity in wastes for dumping.

3.2 The Establishment of a *De Minimis* Level of Dose

3.2.1 Introduction

In choosing a value for the *de minimis* level of dose, a somewhat arbitrary judgement has to be made. Guidance may for instance be obtained from consideration of the balance of the economic penalties and risks between the doses resulting from the disposal of any waste and those associated with further conditioning and deep ocean dumping of the waste. The level of effective dose equivalent which has been chosen is 10μSv (1 mrem) per yearly practice to the average individual in the critical group. This dose comprises the sum of all future external and internal doses from a single year's practice to the average individual in the critical group.

When levels of radioactivity have been established which correspond to the de minimis level of dose, it must be emphasised that this amount of activity is to be included within the total releases of all dumping practices carried out under the terms of the London Dumping Convention. Thus the adoption of a de minimis level of dose does not involve an increase in the total amount of radioactivity which may be dumped under the Convention. The effective dose equivalent of 1 mrem y^{-1} is introduced only for the purpose of application of the London Dumping Convention. It is not intended to be used to exempt the wastes from being subject to radiation protection practices. Rather, the radiological impact that may arise from the dumping of these de minimis wastes should be considered when assessing, for the application of the ICRP dose limitation system, the total detriment caused by the practice.

Other factors which must be considered in addition to those listed in Annex III of the London Dumping Convention include:

a) Long-term impact on marine biota and on man.

b) Relationship of dumped radioactivity to natural background radioactivity in the sea.

c) Feasibility of demonstrating compliance, including general monitoring and reporting requirements.

d) The physical and chemical properties of the material.

Where the material has levels of activity which fall between the definition of that which is non-radioactive and that which is permitted to be disposed of under the 1 mrem y^{-1}, de minimis dose concept, its radioactivity must also be considered in the context of the London Dumping Convention. Thus, while such material may be dumped under a general permit, within the provisions of Annex III only, a reporting procedure is necessary to ensure that due account is made of its activity in conjuction with wastes dumped within Annex II of the Convention. This condition will not apply to wastes defined as non-radioactive similarly dumped under the terms of Annex III.

3.2.2 Specific Recommendations

All human activities entail some element of risk. The applications of radioactivity will give rise to a distribution of doses and hence entail a distribution of risks. At present, it is assumed that the risk to health corresponds linearly with the radiation dose received, without a threshold value. It is relevant however, to consider that level of radiation dose where the associated risk to the exposed individual is insignificant from the viewpoint of the recipient. If such a level of risk can be established it may be used to evaluate levels of radioactivity in the environment which may be considered trivial. Although the establishment of such negligible risk value is far beyond the scope of this report, a discussion of such considerations is included to further justify the conclusion that a dose level can be established, which could be regulated under a general permit of the London Dumping Convention.

Risks to the individual may be voluntary or involuntary. Examples of voluntary risks are activities such as smoking, driving, playing sports etc. The levels of fatal risk in this category varies widely. Risks of fatality due to occupational hazards also vary widely, as listed in Table I.

TABLE I

VOLUNTARY AND INVOLUNTARY RISKS ASSOCIATED WITH VARIOUS ACTIVITIES
(probability of fatality/year)

Work		Leisure		Natural Hazards	
Mining	10^{-3}	Racing	10^{-3}	Worldwide Floods	10^{-6}-10^{-7}
Commercial flying	$6x10^{-4}$	Skiing	$7x10^{-5}$	Earthquakes	10^{-6}
Engineering	10^{-5}	Smoking (20/day)	$5x10^{-3}$	Lightning	$5x10^{-7}$
		Passenger on airline ($20hrs.y^{-1}$)	10^{-5}	Natural Causes (prime of life)	10^{-3}

Thus the concept of a level of risk which is not taken into account by the individual when making decisions concerning their activities is that of a 'negligible' risk. It appears from Table I that this level of risk for voluntary risks is in the range of 10^{-3} to $10^{-5}y^{-1}$.

In a survey of comparative risks experienced by the population, Webb and McLean(1977)[4] have concluded that an annual probability of death of the order of one in a million (10^{-6} per year) is not taken into account by individuals in arriving at decisions as to their actions. This level can be considered negligible. It is proposed to introduce a conservative factor of 10, such that a trivial level of risk may be ascribed to an annual risk of death of $10^{-7}y^{-1}$.

The ICRP in publication 26[5] has given a level of fatal risk from irradiation of $10^{-2}Sv^{-1}$ ($10^{-4}rem^{-1}$) averaged over age and sex. The same conclusions essentially are found with the BEIR[6] report. Thus the risk of fatality which corresponds to an annual risk of death of 10^{-7} y^{-1} is $10^{-5}Sv.y^{-1}$ ($10^{-3}rem.y^{-1}$).

In addition to the somatic effects of radiation, genetic effects may occur in the descendants of the exposed population. Based on a linear dose-effect relationship the additional risks of genetic effects at this dose level will not significantly change the total effects. The insignificant level of total annual effective dose equivalent is thus $10\mu Sv.y^{-1}$($1mrem.y^{-1}$).

3.2.3 Additional Considerations

Natural background radiation around the world from primordial and cosmogenic nuclides is about $1mSv.y^{-1}$ (0.1 $rem.y^{-1}$) and the normal range of variation is generally between 0.5mSv (50 mrem) and 2mSv (200 mrem) per year. This gives some perspective to the _de minimis_ level of dose chosen.

It should be noted that by comparison the dose limit above background recommended for individual members of the public by ICRP is $5mSv.y^{-1}$ (500 $mrem.y^{-1}$) and $1mSv.y^{-1}$ (100 $mrem.y^{-1}$) if actually received over a lifetime.

4. POTENTIAL APPLICATION OF A _DE MINIMIS_ DOSE

4.1 Introduction

The provisions of INFCIRC 205/Add.1/Rev.1, as presented to the London Dumping Convention in 1978, require that radioactive material below specified limits be disposed in the deep ocean basins in packaged form under Annex II of the London Dumping Convention. A qualitative definition has now been formulated for those essentially natural radioactive materials that can be considered as non-radioactive for the purposes of the London Dumping Convention. These materials can therefore be disposed of under the terms of a general permit. Hence, with the establishment of a de minimis dose of 1 mrem/year it is necessary to define quantitatively, those materials not covered by the definition of "non-radioactive" above, yet meeting the de minimis dose of 1 mrem/year. Establishment of these values would define those materials that could be considered from a purely radioactive standpoint as acceptable for inclusion under a General Permit rather than a special permit. Since a number of nations bounding each ocean basin may decide to exercise this option of the dumping of de minimis quantities of radioactive materials in the oceans, it will be necessary to apportion the total ocean basin quantity of radioactivity derived from the de minimis dose among them. Of course, this will depend upon the potential users, in the future, rather than actual users today, and for initial planning purposes, it is recommended that no single nation shall exceed one-tenth of the limit or $1 \mu Sv.y^{-1}$ ($0.1 mrem.y^{-1}$) for dumping radioactive material under a general permit. It should be emphasized that establishment of these quantities outside of national waters must be considered within the total capacity of the ocean; that the de minimis dose is applicable to all populations bordering the ocean basin; derived amounts of radioactivity must be included within the release rate limits recommended in INFCIRC 205/Add.1/Rev.1 of 1978; and although these quantities are small, it is important that they be included within the established reporting systems for Annex II to ensure that the upper limits to the annual release rates (INFCIRC 205/Add.1/Rev. 1) are not exceeded.

4.2 De Minimis Dose Conversion

Dose is a measure of the effect of dumping and, as also the fundamental criterion for protection of man, it is the correct basis for defining waste which may be regarded as harmless. However, dose is not in itself a quantity of any direct, practical value when considering sea dumping of radioactive waste. It is therefore necessary to convert dose into a quantity which can be either measured in the waste, such as concentration of constituent radionuclides or which can be readily computed from it, such as a rate of disposal. Conversions of this kind pose a number of problems which require resolution.

A major concern is one of uncertainties in the dispersion models. While it is relatively easy to make short-term predictions and to handle relatively short half-lived radionuclides, we lack a detailed understanding of the mechanisms of radionuclide transport and accumulation over great distances and often long time scales. The result is that the relationship between the rate of disposal and dose to man can only be treated in an approximate and largely empirical fashion.

A need to ensure protection in the far distant future to the same extent as within our own timespan is morally indisputable. Moreover, the consequences of attempting to cater for very long term operations become important for the long-lived radionuclides. This is partly due to the fact that assumptions made today may not prevail in the future such as the rates of geochemical cycling, climatic factors that may affect the size and characteristics of the oceans, the nature of the human population so far into the future, and the resources that they might use.

An additional concern is that at the low levels of radioactivity that conform to de minimis, the rate of release will generally be poorly known.

This release rate may not necessarily be equal to the dumping rate, though for practical reasons it is usually taken to be so. Average release rates over long time periods will not exceed the dumping rate, and for short-lived radionuclides will be less, so the assumption is conservative.

Timescales are also important for long-lived radionuclides. The models assume that these radionuclides remain in solution though the present evidence suggests that the sediments will be the major repository for transuranic elements, and that massive remobilization due to natural chemical processes is unlikely to occur beyond an expected equilibrium desorption. When considering the dumping and disposal of radionuclides other than at de minimis levels, the prudent approach has been to err on the side of safety and to adopt conservative values throughout. This ensures that dose levels will be maintained well below any upper limit that may increase the risk to man. However, in the context of establishing de minimis quantities of radioactivity that may be disposed of to the oceans, the conservative approach will ensure that all wastes established as de minimis are properly so included, the very concept is that at these levels the risk is trivial. Hence, no additional restraints should be applied since these would result in an unjustifiable use of resources.

The remedy to the latter is not the use of optimization procedures (ICRP 26) which more properly should be applied before issuing special permits, but rather to obtain additional information to provide a better understanding of the transport and pathway processes. This would reduce the conservatism in determining the de minimis quantities that can be dumped in the oceans. These are the fundamental concerns that confront those responsible for converting the de minimis dose to release rates.

In addition it will also be necessary to resolve the questions of time-scale of protection and the unit quantities into which the dose is converted. The criterion for de minimis established in 3.2.3 is that no individual should receive an effective dose equivalent in excess of 1 mrem in a year and at that level the risk is trivial. While it is quite appropriate under a special permit to express this in terms of an effective dose equivalent commitment it may not be appropriate for de minimis levels. By expressing this as a dose commitment for de minimis quantities, it is implied that the practice may continue for long periods of time for the per caput dose rate reaches 1 $mrem.y^{-1}$. This may be unduly restrictive for long lived radionuclides bearing in mind the de minimis definition. Therefore, it may be necessary, for other reasons, to express this as a truncated dose commitment - the period of truncation perhaps being either the dumping practice duration or the mean half-life of a long-lived radionuclide, such as plutonium-239.

The question of the numerical unit into which the dose should be converted also needs to be resolved. The most soundly based, in scientific terms, is the release rate, since it can then be compared most readily with inputs from other sources i.e., special permit operations, liquid releases from nuclear installations and fallout from nuclear weapon testing. The principle argument presented by the IAEA and IMCO against the release rate unit stems from the difficulty of administering a given release rate computed for an ocean basin to which several countries release radioactivity. For the special permits for dumping packaged wastes to the deep ocean the IAEA proposed a mass dumping rate (Tonnes) which when divided into the release rate (Ci/y) established the maximum concentration allowed (Ci/t/y). It follows that provided the concentration and the mass rate are not exceeded then the established dose limitation will be met. Again it seems questionable whether the risk at de minimis levels should be subjected to the same regulatory concern. The proposed repository requirement (4.1) of the total quantity of radionuclides disposed of under the de minimis provision in order to control the total quantity in an ocean basin may be adequate. The quantitative establishment, in any generic way, for these materials which may be dumped in the oceans, other than under the conditions defined for special permit materials, is not an easy task since full consideration has to be given to the large differences that exist on the continental shelves and adjoining seas of any given ocean basin.

4.2.1 Assessment from oceanographic and radiological models

The primary approach that should be considered for the conversion of the de minimis dose to permissible radionuclide release rates on the continental shelf and nearshore regions is the critical pathway approach (ICRP 26,[4] IAEA 211,[7] CEC 1979[8]). This approach involves first assessing the maximum sustainable concentrations of radionuclides in defined bodies of surface waters that could result in a maximum radiation dose of 10μSv/yr (1 mrem/yr) to the average individuals in the critical group.

These maximum radionuclide concentrations can then be maintained in perpetuity by nearshore disposals of waste based upon similar assumptions to those made in the development of namely, INFCIRC 205/Add.1/Rev.1, that for the purposes of critical pathways involving aquatic organisms, all the dumped radionuclides are assumed to become entirely dispersed in the overlying water column and that, for critical pathways involving sediment-dwelling organisms, these same radionuclides remain in the underlying sediments. Having made these assumptions there exist differing degrees of refinement which can be used in calculating the permissible disposal rates by which the radionuclide concentrations are maintained.

In one instance, permissible discharges can be equated solely to the integrated decay rate of radionuclides in the water body within which they are initially dispersed. Thus, discharges are permitted if they just balance the in situ decay of a radionuclide in the water body. Such a calculation neglects dilution of the radionuclide concentrations by mixing with adjacent water bodies containing lower radionuclide levels. It does, however, require a realistic estimate of the volume of water into which initial dispersion takes place. Only that fraction of the assimilation rate, so defined, which is not utilized by other anthropogenic radionuclide discharges can be used for the purposes of nearshore dumping. Nevertheless, since other forms of removal than radioactive decay are neglected, it is a restrictive or conservative model. An alternative approach to the calculation is to assume that both radioactive decay and mixing will control the ambient levels of dumped radionuclides in the water. Thus, the relationship between the concentration C and the discharge rate S of a radionuclide into a basin of volume V having water residence time τ, flushed by water from another basin of volume V_0 having radionuclide concentration C_0, can be expressed as

$$\frac{dC}{dt} = -\lambda C - \gamma(C - C_0) + \frac{S}{V}$$

where $\gamma = \frac{1}{\tau}$ and λ is the decay constant of the radionuclide. Similarly the concentration C_0 of the radionuclide in the adjoining basin from which flushing water is supplied can be written

$$\frac{dC_0}{dt} = -\lambda C_0 + \frac{\gamma V}{V_0} (C - C_0)$$

These equations can be solved to yield values of S which correspond to permissible values of C and C_0 under steady state conditions (derived from IAEA 211) starting from initial values of $C = C_0$ at $t = 0$.

In the application of such concepts to the real environment, it is probably more reasonable to deal with a larger number of interrelated water bodies than just two. A set of nested basins of this type could suffice to describe more accurately the true physical conditions of mixing. It must be appreciated that an inherent assumption in this approach is that internal mixing is achieved on time scales much shorter than the flushing time τ. This will impose a severe limit on the degree to which a general box-type calculation can be applied to individual regional sea or shelf waters.

A major problem which arises in the application of both these approaches is to decide upon the particular volume of water into which the radionuclides initially become dispersed. It seems inevitable that national radiological protection authorities will have to decide on the safety of any nearshore disposal practices in regard to the local population. The more general (geographically broad) is the type of calculation discussed above, the larger will be the population which has to be protected by ancillary calculations. At one extreme, one could assume mixing throughout entire surface layer of a particular ocean basin, e.g. the North Atlantic mixed layer. Such a choice would provide very limited protection to inhabitants of regional seas into which discharges might be considered, thus increasing the extent of the population to be covered by such ancillary calculations. Furthermore, the use of the ocean mixed layer for initial dispersion obviously neglects the dynamics of ocean basins in which horizontal advection can increase the risk to distant populations over that which would arise if mixing were uniform. A small and more reasonable volume of water to consider would be that of typical regional seas, e.g. the North Sea, Irish Sea and the Gulf of St. Lawrence in the case of the North Atlantic. Such choices would limit the sizes of populations to be considered by national regulatory authorities in ancillary calculations but it is still difficult to be satisfied that internal mixing times in these water bodies are short compared to inter-basin exchange times. The bodies of water into which initial dispersion occurs may be long-shore currents which subject populations in adjacent countries to increased risks compared with other populations bordering the sea. Unless such water masses can be treated as the primary volumes for radionuclide dispersion in oceanographic calculations, it becomes essential that national regulatory authorities consider such risks to the populations of neighbouring countries if transboundary advective transports are important in the area of intended dumping.

The periods over which disposal of radionuclides in shallow water regions is to be considered is less of a problem than in the case of deep sea disposal. Water residence times in surface waters and shallow basins are quite short compared to oceanic mixing times. The residence time of water in the ocean surface layer is about 20 years

(Goldberg et al 1971)[9]. Thus on a large scale, steady state conditions would be virtually attained within a century. Inhomogeneities in the distribution of short-lived radionuclides can be assessed to allow for increased disposal rates if protection of local populations can be assured. Furthermore, unlike the case of the deep ocean, better knowledge exists regarding the behaviour of radionuclides and their stable analogues in the ocean surface layer. It therefore appears possible to consider the scavenging and removal of radionuclides from surface waters by biological and geochemical processes.
Comparisons of the residence times of radionuclides with that of water in the surface layer can then be used to improve the realism of the model. It must be remembered that such processes will accelerate injections of radionuclides in the deep ocean. Nevertheless, assuming that all dumping carried out under the de minimis provisions will be accounted for as part of the limits established in INFCIRC 205/Add 1/Rev 1, this should not present a serious difficulty.

In order to achieve this conversion it will be first necessary to develop a series of physical oceanographic models reflecting the interrelationships between adjoining nearshore bodies of water, the open ocean and the adjoining ocean basins in order to arrive at the maximum sustainable concentrations of radionuclides in the water. The radiological assessment will then be required to develop the appropriate critical pathways on a regional basis, or if that information is not available, on a generic ocean basin basis, reflecting the probable future uses of the ocean resources.

4.2.2 Other approaches

Two other approaches were discussed: Since we are only concerned with de minimis quantities of radioactivity, it would be beneficial if we could develop an approach that would avoid the problems created by uncertainties in the oceanographic and exposure pathway modelling; in physical and geochemical cycling mechanisms; would be site independent of and not influenced by the characteristics of the environment receiving the wastes; and moreover, would provide a rational basis for agreement between all countries with a common interest in dumping within the same ocean basin.

4.2.2.1 One approach, the specific activity concept, was recommended by the U.S. National Academy of Science/National Research Council for the Disposal of Low-Level Radioactive Waste into Pacific Coastal Water (NAS 1962) [10], but was never implemented.

The specific activity is defined as the ratio of the concentration quantity of the radionuclide to the concentration of the stable analog (expressed as pCi/g). As applied to this situation, the approach depends upon being able to compute a specific activity for a radionuclide per unit mass of the stable analog in the whole body tissue or body organ that is under consideration.

The principle underlying the use of this method, is that, if the specific activity (as so defined) in the waste material or the seawater is within this value, then there will be virtual assurance of the resulting dose to man being within the de minimis value. This is because the specific activity will not increase along the physical/chemical/biological pathways. Rather the specific activity will either remain the same or it will decrease as mixing of the material containing the radionuclide occurs with its stable analog in the environment - resulting in a lower specific activity. On this latter, the much more likely situation, it is expected that the method would prove to be conservative, probably highly so.

Despite the apparent attractiveness of this approach, there are a number of reservations to which the method is subject. Firstly, the concept only holds when the radionuclide and its stable analog are present in the environment in the same physical/chemical/biochemical form, displaying the same biological availability from the outset or have equilibrated before the material comes into contact with more of the radionuclide and its stable analog. This is likely to be assured for radioactive materials where the radionuclide is present due to neutron activation or where the chemistry of the radionuclide and stable analog is similar. There are certainly some radioactive nuclides for which the method is valid. Secondly, the application of this method is limited to situations where internal organs are critical and it cannot be used where the critical organ is the gastro intestinal tract. With the advent of the weighted whole body dose concept of ICRP, this latter problem might be overcome; however, simultaneous with this development, the ICRP have moved away from specification of body or organ burdens of radioactivity on which, together with the stable analog content of body organs, the calculation of values of specific activity for this purpose depends. It may therefore, be difficult to develop an approach that meets both the existing and proposed concepts.

Thirdly, the use of method excludes the natural heavy radionuclides with an atomic number higher than 82, the transuranics, promethium and technectium. There is some evidence that the method can be used for some of these by reference to an element of similar nature, e.g., another rare earth would be used to derive specific activity for promethium. Nevertheless, the concept is worthy of further consideration if only because it is unique amongst approaches in obviating the need for apportionment of dose and the definition of environmental rates of introduction of radionuclides.

4.2.2.2 Comparison with levels of primordial cosmogenic and anthropogenic radionuclides in the marine environment

Finally, another approach was discussed that could be applied to selected wastes. There are numerous natural and some artificial radionuclides which are widely distributed in the marine environment and whose levels may provide a perspective against which to judge the effect of dumping of wastes containing very low levels of radioactivity. Although detailed assessment of the radiological consequences on man at these levels of radionuclides is lacking, not even available through the work of UNSCEAR except in terms of, e.g., the dose from total diets, it was felt that their radiological consequences are very small. Hence, if dumping of wastes were to result in concentrations in these materials not significantly greater than these levels, such wastes could be regarded as conforming to a *de minimis* requirement.

Concentration values are available in the literature for selected materials in the three basic compartments of the marine environment; namely, water, sediment and biota. These data are subject to further qualifications, particularly that a range of values will often exist, even for a single species. It may be thought that the most helpful values would be those from nearshore zones because these are more likely to have a direct impact on man, than values which relate only to the open ocean. However, in the case of fallout radionuclides, the levels in nearshore zones are sometimes masked by the other sources for which the premise of a very low radiological consequence may not apply. Data for fallout radionuclides should only be included where there is no significant component from these other sources.

A qualification that applies to all radionuclides is that a range of values exists which reflects differences in the basic characteristics of the actual material which has been sampled. This is especially true of sediments, with ranges of 10 to 100 not uncommon between fine-grained sediments rich in clay minerals and coarser-grained sands. There are variations, too, between species of fish for specific radionuclides (though general of a small range) and this effect is also seen in seaweeds and shell fish.

Should the concentrations as a result of dumping be found to be below the established ambient levels, the waste will certainly conform to a de minimis principle for radioactivity. However, while the end result appears acceptable in a qualitative sense it will be practically impossible to predetermine that the resultant dose meets the de minimis dose requirements. This approach is not recommended.

5. CONCLUSIONS AND RECOMMENDATIONS

The Advisory Group has formulated a qualitative definition of non-radioactive material which can be used for the purposes of implementing the procedures specified under the London Dumping Convention. This definition provides a convenient and practical vehicle for distinguishing between wastes which must be considered as radioactive and those which may be dumped under the provisions of the London Dumping Convention without consideration of their inherent radioactivity.

The Advisory Group then went on to consider a de minimis level for radioactive wastes. It was concluded that the only simply applicable de minimis concept was one based upon radiation dose. The total annual effective dose equivalent to an average individual in the critical group rising from all sea-dumping operations under general permits should not exceed 10μSv (1 mrem). This recommendation has been formulated in accordance with all internationally-accepted radiation protection principles. It is emphasized that the application of the de minimis dose concept must not be construed as an exemption from considering the total radiological impact resulting from the conduct of any given practice producing radioactive waste.

The problem that then arises is the conversion of this de minimis dose into values of radionuclide discharge rates (or concentrations) in potential dumping materials. An effort has been made in the case of other hazardous substances, specified under the London Dumping Convention, to express the equivalent of de minimis levels in terms of mass concentration in the waste material. We have concluded that this is a difficult task to undertake in the case of radioactive wastes but we have specified several approaches which might allow such numerical values of concentrations to be derived from the de minimis dose value.

In view of the above conclusions, if the IAEA determines that a conversion from de minimis dose to activity per gross mass is needed, the Advisory Group recommends that the IAEA proceed to develop the scientific basis for such conversions through the use of expert consultants and advisory groups.

It was concluded that continuity of technical concepts was important and it is recommended that technical experts from this advisory group should be present at all further meetings concerning the subject of "de minimis quantities" of radioactive waste.

References:

1. London Dumping Convention
INFCIRC/205 (1974) "Convention for the Pollution of the Seas by Dumping of Wastes and Other Materials", London

2. "IAEA Revised Definition and Recommendations Concerning Radioactive Wastes", INFCIRC/205/Add.1/Rev.1 (1978)

3. IAEA Safety Series # 45 (1978)
"Principles for Establishing Limits for the Release of Radioactive Materials into the Environment", Vienna

4. Webb, G.A.M. and McLean, A.S. (1977) "Insignificant Levels of Dose" Harwell - NRPB,R 62, London

5. ICRP #26 (1977) "Recommendations of the International Commission on Radiological Protection" Annals of ICRP 1

6. BEIR Report (1972)
National Academy of Science "Biological Effects of Ionizing Radiation" Washington DC, USA

7. IAEA #211 (1978) "The Radiological Basis of the IAEA Revised Definition and Recommendations Concerning High Level Radioactive Waste Unsuitable for Dumping at Sea"

8. CEC (1978) "Modelling of Artificial Radioactivity Migration in Environment: a Survey" , EUR 6179 EN by Bignoli, G., and Bertozzi, G.

9. RIME (1971)
"Radioactivity in the Marine Environment" National Academy of Sciences, Washington DC., USA

10. NAS - NRC (1962) "Disposal of Radioactive Waste into Pacific Coastal Water", Pub. # 985.

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