III Radioactive and Toxic Wastes: A Comparison of their Control and Disposal

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The control and disposal of radioactive wastes is based firmly on radiological principles. That statement may appear to be a truism, something which need not be said. But an Act of Parliament is not just a statement of scientific principles with a legislative structure for applying them; it incorporates also the traditions of control in related fields and the views of elected representatives and the views of sectors of the public (as expressed by relevant associations), which will have been sought in preliminary consultation. The end-product, the Act of Parliament, is some compromise in which the technical principles are not necessarily dominant. However, the technical principles (as enunciated in a White Paper which was widely supported) of the Radioactive Substances Act 1960 are indeed dominant, with but little modification by political principles.

The technical principles, not so clearly accepted in 1958 when the proposals for legislation were being considered as they now are, following ICRP and other publications, may be stated for our purpose in fairly simple terms, though each principle, as with other technical principles, is not nearly so simple as it looks and might be elaborated without undue difficulty into a volume of discussion and refinement and criticism. For effective legislation, simple, clear principles are essential; each reservation, however well based, will probably require a Section in the Act and ultimately, if too many are included, a clumsy, cross-referenced Act will probably emerge. Unless the reservation is a major one it will probably have to be sacrificed in the interests of writing clear, effective legislation.

The principles are:

(*a*) that the permissible levels recommended by the ICRP, which are expressed in terms of doses of radiation either to the whole body or to an organ of the body, are a proper basis and should not be exceeded irrespective of cost;

(*b*) that doses of radiation (but not necessarily amounts of waste disposed of) should be reduced as far as is readily achievable, economic and other factors being taken into account.

From these simple principles several deductions can be made:

(i) Only irradiation of man is to be taken into account: the effect on animals would be considered only in so far as man is affected.

(ii) Similarly, so long as the irradiation of man is not affected, environmental effects *per se* are not taken into account.

(iii) For any disposal of radioactive waste a derived working level may be

> deduced by straightforward (in principle) calculation: from the observed environmental behaviour of the radionuclide and the observed habits of man, utilizing the known radiation of the radionuclide and the known characteristics of man, one may calculate that level of disposal which just does not produce the permissible level.

Thus the control of all disposals of radioactive waste is based in principle on a logical set of assumptions and deductions applicable to all the toxic substances which fall in the sub-set of radioactive substances in so far as their toxicity is attributable to the ionizing radiations they emit. The discussion of the validity of the control can concentrate then on the validity of the assumptions, one of which must be mentioned for our present purpose.

Our knowledge of the effects of ionizing radiations on humans derives for the most part from observation of the effects of single relatively large doses. In order to deduce a permissible level applicable to perpetual or life-long irradiation it is necessary to deduce the effect of the latter from that of the former, guided by animal experimentation; that is, a mathematical relationship has to be assumed for extrapolation (*a*) from high does to low dose, (*b*) from acute exposure to chronic exposure. (Again, I am simplifying the issues.) The extrapolation used by ICRP assumed that the former is linear and that the latter is an equality; deliberate, conservative assumptions.

It is sometimes asserted that because a linear relationship is assumed to represent the data at high doses and is used to extrapolate to low doses, then it is legitimate to carry the linear extrapolation further to zero, or rather indefinitely small dose; and then it would follow that any dose of radiation, however small, would produce some effects, implying that no irradiation should be tolerated, however small, unless for very good reason. It is important to be clear that the argument is false. The conclusion is not, however; as a matter of common prudence and following well-established principles in the public health field, any pollution which may affect man's health — and perhaps that means any pollution — should be avoided, if practicable. The real problems and the art of public health control follow from the balancing of the two, the risk *vs.* benefit. But this attitude and this problem are not peculiar to radioactive waste control.

One other factor in radioactive waste control has to be noted, the extreme sensitivity of the analytical techniques. One may be permitted to speculate whether such low permissible doses would have been specified if the analytical techniques for measuring them had not been possible; as it is, some of the derived working levels are on the edge of measurability, and 'as low as readily achievable' or 'reasonably practicable', or whatever phrase is used, seems to be interpreted sometimes as 'just measurable'.

A detailed account of how the U.K. system of control of radioactive waste disposal under the provisions of the Radioactive Substances Act 1960 operates in practice has been published;[1] the essentials may be summarized as follows:

[1] A. W. Kenny and N. T. Mitchell, 'Management of Low- and Intermediate-Level Radioactive Wastes', International Atomic Energy Agency, Vienna, 1970, p.69.

(*a*) All users of radioactive substances, except those exempted by Order, must register with the Secretary of State. Since there is power to refuse registration, there is in effect power to ban a particular use or any use by a particular user for reasons related to waste disposal. That power clearly must be exercised only by the central government.

(*b*) All disposals of radioactive waste, except those exempted by Order, must be authorized by the Secretary of State.

(*c*) Disposal of radioactive waste by conventional methods of waste disposal, whether operated by local authorities or private individuals, is encouraged, but

(*d*) For those wastes which cannot be so disposed of, a National Disposal Service, based on the facilities developed for their own activities by the U.K. Atomic Energy Authority and British Nuclear Fuels, is operated by the central government, the service being provided at cost.

The control of radioactive wastes has been approved by the Royal Commission on Environmental Pollution,[2] the caveat in respect of stored fission products being non-pertinent to the controlling Act. It is then an acknowledgedly successful system of control; one Act for all radioactive waste, whether solid, liquid, or gaseous. By contrast, the disposal of other wastes is controlled by three series of Acts, one for each of the phases, and in the three phases domestic waste control is mixed up with the toxic waste control.

Before going further it is well to chew over the phrase 'toxic waste', without, however, breaking our teeth or choking on it. It is not of course an antonym of 'radioactive waste' or of 'domestic waste' and it is not a synonym of 'industrial waste'. If the comparison of the control of radioactive and toxic waste disposals is to be of value, the phrase must be restricted in meaning to wastes containing or contaminated with substances which in the normal way are considered to be dangerous. Yet the legislation must control a wider range of substances along with or parallel with toxic wastes, and to some extent the two get mixed up.

The present situation is somewhat as follows:

(i) In regard to wastes (dusts, mists, and gases) discharged to atmosphere, Orders made under the general enabling provisions of the Alkali Acts have specified the classes of industrial premises to be brought under their control. Levels geared to what is practicable, having regard to the methods of treatment available and the nature, including age, of the plant have controlled existing emissions and ensured that new factories use the best practicable means for treatment.

(ii) In regard to wastes discharged to sewers and rivers, the local authority and the River Authority, respectively, have the power to specify limits for constituents of the discharges. There is no regard necessarily to what is practicable or what is economic, the interest of the sewerage system (including the treatment works) and the river, respectively, being para-

[2] Royal Commission on Environmental Pollution, Third Report: 'Pollution in Some British Estuaries and Coastal Waters', HMSO Cmnd. 5054, London, September 1972.

mount, but the authorities do, of course, have regard to what is practicable, and in the last resort an appeal to the Secretary of State may be made.

(iii) In regard to solid wastes discharged to land or to sea, until quite recently there was no controlling legislation, and even now the control is quite loose. Proposed legislation would give the Secretary of State the power to specify wastes which would become subject to an authorization procedure enforced by the local authorities.

This very brief summary omits the contribution of civil law and private Acts, and also omits the effect of Acts designed to control smoke emission from private dwellings, which of course is not ordinarily regarded as industrial waste disposal. The law of nuisance, riparian rights, local Acts imposing conditions on waste tips (especially in the Home Counties), and in some cases planning controls; all these have made notable if sometimes local contributions to the control of waste disposal. It would take us too far if we were to pursue this topic; it is noted merely to warn the reader that the summary is given in order to develop the comparison which is our present purpose, and is in no sense complete.

The logic of separately treating non-radioactive wastes in the three phases of matter is fairly clear. When such a waste is treated, its toxic or offensive nature is destroyed; dust is trapped and no longer inhaled, organic wastes are oxidized, acids are neutralized, and so on. Though there are exceptions (arsenic, for example) it is broadly true that toxic substances may be destroyed. With radioactive wastes, treatment merely transfers the toxic element to another phase, in which either it may be safely disposed or it may be contained, either permanently or until sufficiently decayed. One may deduce that toxic wastes whose toxicity cannot be destroyed by treatment are probably best controlled by comprehensive legislation applicable to the waste, in whatever form it may arise.

The next point we may take is the emphasis in the control of radioactive waste on reducing irradiation of people to the lowest reasonably practicable level. I have argued that this does not follow from any technical aspect but is mere prudence. Indeed it can never be possible to prove that any substance has no effect when inhaled or ingested in vanishingly small concentration for a lifetime; it is just not possible to perform the experiment. So to take a case at random, we cannot be certain that the trace metals in drinking water have no effect whatever on the population supplied with the water. There is the same reason for restricting disposal of non-radioactive waste or, to be more accurate, for keeping environmental contamination to the lowest reasonably practicable.

In the control of emissions to atmosphere under the Alkali Acts, this philosophy of best practicable means has been followed, and in the control of discharges to rivers one has seen the same process of gradually tightening the permissible limits not specifically because the former limits are thought to be toxic but because there is a widespread feeling that what was provided originally by Nature, namely the environment in which man has evolved, is probably a good target to aim for. A similar feeling perhaps is behind the argument that

sewage discharged to sea should be treated even though there may be no visible contamination and despite assurances that there are no medical hazards.

The concept of what is reasonably practicable is subjective and required some balancing of risk *versus* benefits. Some approach to the evaluation of risk has been made in the radioactive field (but it is subject to the assumptions previously discussed in extrapolating the data); with toxic substances one cannot begin to make the assessment, so meagre are the data. The benefit accruing from the use of a substance cannot usually be expressed quantitatively. Finally, in the assessment, the balancing of risk against benefit, one is comparing two things which cannot be expressed in any units and certainly not in the same units.

In the ultimate, if one concludes that the risk from waste disposal is not justified, the use may have to be banned. The power to do so has been taken in the legislation controlling radioactive substances but it has not in fact been necessary to use the power. On the other hand, the uses of two non-radioactive substances have been controlled, if not actually banned (although no legislative power of control exists) by voluntary industrial action, *viz.* hard synthetic detergents and polychlorobiphenyls (PCB's).

The former are substances that were used in every household, which, when not biodegradable, caused unpleasant foaming at sewage works and in rivers and passed into drinking water, where they were present in amounts which, though not toxic, were undesirable. The latter were widely dispersed in our environment. There is still no evidence of harm to man but some reason to suspect harm to certain birds. Their use is now confined to those situations where no adequate substitute exists — a deliberate application of the cost-benefit principle.

A ban on the use of a substance, however achieved, must be nationwide; the power to ban must rest with the central government and could not be given to local government. Even a national ban may not be effective because imports cannot be wholly controlled in practice, even if within the system of world-wide agreements on trade it is in fact possible to make effective international agreements to limit or ban these substances. There is always the possibility that a national ban will be undermined by imports from other countries who, legitimately making their decisions under the cost-benefit principle, reach a different conclusion from ours. The benefit seen depends on the state of economic development of the country. The foaming of synthetic detergents may be tolerable in a country where sewage treatment works are not widely provided, and where water is drawn from wells. The risk, such as it is, from heat-treatment cyanide that has been discarded in the countryside may be tolerated in a country which sees the economic burden of treatment or sea disposal as money best spent elsewhere. Thus the effect of a national ban may be to drive the industry elsewhere, while still not achieving the complete ban on use which was the object of the legislative ban.

In the radioactive field, principally one supposes because the toxic effects of all the substances are based on a common effect and may be evaluated on the basis of an agreed set of assumptions, there is a wide international agreement,

which, for example, has enabled the United Nations SCEAR Committee to publish internationally acceptable conclusions on the hazards of fall-out from nuclear tests, despite the emotive content of the subject. While this does not completely remove the possibility of nations objecting unilaterally on other than technical grounds, at least there is agreement on the technical issues, and the political arguments can be debated in the appropriate forums.

The recommendations of the ICRP are accepted internationally, with a consequent international basis for international banning of prescribed uses of radioactive substances if that were thought desirable. There is no similar organization for other toxic substances, though the world monopoly or semi-monopoly status of international companies can operate in substitution, and perhaps just as effectively. At present one can merely note that a banning of use, though a desirable and probably essential element in any legislative system of control of waste disposal which aims to be comprehensive, is not necessarily as effective as one might hope.

Complementary to this notion is the banning of a particular method of disposal for a particular substance. In the long run there are but three methods of disposal: (*a*) to dilute and disperse; (*b*) to concentrate and contain; (*c*) to treat and destroy; with the added bonus in the case of radioactive substances that containment affords time for decay and then in effect is a treatment process. The same bonus could come from unstable chemical substances.

Of these methods, the first is environmentally most sensitive, and where disposal to the seas is involved, internationally most sensitive. In the U.K. our industry is so close to the sea that it may often be the preferred sector of the environment for getting the dispersion needed for safe disposal; and the sea is most liable to international control, though the atmosphere is an obvious close second. Clearly, any international ban affecting dispersion in the seas, as in the Oslo and London Conventions, has repercussions forcing the adoption of other methods of disposal.

In the case of radioactive substances, the third method is not available, except in so far as decay is so accounted, and the inevitability of producing super-lethal amounts of fission products as by-products of nuclear power has compelled the development of the second method. Thus the U.K. nuclear industry has comprehensive and adequate facilities for waste disposal based on the first two methods, and a keen interest in preserving the first in order to reduce the cost and potential danger of storage involved in the second, an interest which will be warmly supported as obviously desirable nationally. Since this industry is and always has been nationalized in effect, the facilities are national.

Consequently there exists in the radioactive field a fall-back position; the national facilities can be made available for disposal of any radioactive waste whose disposal by conventional methods (*i.e.* to atmosphere, rivers, unsupervized land, or the seas) cannot be authorized. In the legislation, this was given effect by empowering the Secretary of State to set up a National Disposal Service, which he has done through the agency of the nationalized bodies. Thus in the radioactive field there is always some method of disposal; if the cen-

tral government bans a suggested method of disposal by refusing authorization, it provides an alternative method.

There is not the same urgency for a National Disposal Service in the non-radioactive field because the third method of disposal normally provides an adequate alternative to the first and because the absence of large quantities of toxic by-products means the absence of special containment facilities. Even when treatment for destruction is not practicable, as with arsenic waste, the quantities which arise can be dealt with by the first method without recourse to the second.

The principle of requiring an authorizing body to specify, if not actually to provide, an alternative method of disposal for a waste whose suggested method of disposal it is not willing to authorize is surely sound. Authority without responsibility is fraught with danger. For non-radioactive wastes, there was not until the last couple of years, when the UKAEA at Harwell instituted a comprehensive service in this field as part of a general plan of diversification from radioactive work, a national disposal service, though several private firms offered what was virtually a comprehensive service. Of course, there is no real parallel with the radioactive field since, except for certain toxic substances used for military purposes, there is no national industry manufacturing or using toxic substances and therefore no disposal service on which to base a national disposal service. The Harwell service is to some extent a development of the techniques used for disposal of radioactive wastes, with the emphasis on specially toxic substances, for which the techniques are well suited.

In the radioactive field the encouragement to use conventional methods of disposal is based on two principles:

(*a*) it is likely to be the cheapest method,

(*b*) the National Disposal Service should not be cluttered with trivia.

There is an economic element also in the latter. Since a virtually comprehensive disposal service exists in the non-radioactive field, the same principles should hold. The encouragement of this policy, in fact its enforcement by central government with the co-operation of local government through statutory consultation, is effected through the authorization procedure. The authorization procedure need not necessarily be operated through central government, though some mechanism for near uniformity of standards is probably desirable.

The contrast here between the radioactive and non-radioactive field is stark. There is a considerable body of knowledge about the environmental behaviour of radionuclides in waste, much of which is applicable to inorganic or perhaps toxic metal wastes; but most of the knowledge relates to inorganic substances, and practically no information at all exists about the behaviour of organic substances such as arise in wastes from the modern chemical industry. Moreover, the behaviour of inorganic substances as deduced from radioactive waste disposal is not too well known outside the radioactive field.

Lack of knowledge will inhibit the application of the principle of local disposal, where applicable, since the authorities responsible for our water supplies, a valuable asset, will not be likely to take chances. Meanwhile, industrial wastes

may be transported long distances to sites known to be safe for fear that nearer sites known to be probably safe may not in fact be so. There is an urgent need for research both in the laboratory and in the field to throw some light here and to guide future policy. The research has been initiated by the central government in respect of disposal to land where this lack of knowledge is most acute.

With all legislative systems a difficulty arises in exempting small amounts. The normal procedure is to state the principle in the Act itself, and then by Regulations or Orders to exempt from the restriction of the Act those substances which contain less than a specified amount or concentration of the toxic constituent. Our lack of knowledge in this field makes it extremely difficult to envisage Orders based on universally accepted levels such as have been made under the Radioactive Substances Act 1960 (though even these have their arbitrary aspects).

The notification of deposit required under the provisions of the Deposit of Poisonous Waste Act 1972 was subject to such an exemption procedure. The Regulations made under it specified a wide range of wastes which, provided they did not give rise to an environmental hazard, could be deposited without notice. By ignoring (in the interest of simplicity and ease of operation) amount and concentration as parameters determining the toxicity of the waste, a rough and ready classification for this purpose was made. In practice the classification has been used to specify wastes which may be deposited anywhere (*i.e.* the non-notifiable) and those which may be deposited only at specified safe sites (*i.e.* the notifiable).

Whilst this has actually meant a more relaxed attitude to the disposal of certain industrial wastes with domestic waste on local authority tips, it has meant a tightening up on the attitude towards notifiable waste. The hope must be that with more knowledge we can transfer wastes from the notifiable to the non-notifiable class.

In the past there has been no duty of local authorities to dispose of industrial refuse, though they had a discretionary power to do so. Some private waste-disposal firms have used the potential absorbing capacity of decayed domestic waste for industrial waste disposal, and many local authorities have in fact taken industrial wastes. Their experience, supplemented by the research results, may lead to wider public acceptance of this method of disposal.

Before summarizing this study of how far one may apply the principles of control of radioactive wastes to the control of other toxic wastes, a word of caution is in order. Though the successful control of radioactive wastes is a tempting start for formulating a comprehensive system of control for other toxic wastes, it is not the only possible approach. By any standards the striking improvements in our urban atmospheres and in our river waters in the last decade or so are also promising lines along which to proceed. These lie outside the present study but have to be explored in order to formulate the proper control for toxic wastes.

A second factor briefly referred to previously is the non-technical or what may loosely be called the political factor. This is not just a matter, or not even

primarily a matter, of the compromising or give-and-take that is normal to the balancing of interests which play some part in most legislation. However technically perfect a system of control may be, it cannot be successful if it is not widely accepted or if it is not accepted by those most affected and those who have to enforce it.

Then we may summarize the results of our enquiry into how far the principles of control of radioactive wastes may be more widely applied as follows:

(*a*) For chemical substances whose toxicity cannot be destroyed by chemical or biological treatment, or by extension cannot readily or reasonably economically be destroyed, effective control of disposal is possible by legislation similar to that of the Radioactive Substances Act.

(*b*) In general, there does not appear to be a need for a National Disposal Service for toxic substances similar to that for radioactive wastes, and there is not the same economic reason for providing it because there is not a (virtually) nationalized industry already operating a comprehensive disposal service for its own needs.

(*c*) By extension of the principle, however, it might be desirable for a firm placed in a similar position to the nationalized radioactive industry (because of a near-monopoly, say) to provide a similar service for wastes containing its toxic product. But however desirable, any attempt would probably founder on the oft-expressed reluctance of manufacturers to do other than manufacture, and on the reluctance to take responsibility for an ill-defined and possibly dangerous substance.

(*d*) It is probably not desirable to develop comprehensive legislatory control of disposal of toxic wastes, in whatever phase of matter, as obtains for radioactive waste, though an exception might be made as in (*a*).

(*e*) As an ultimate control of waste disposal, ban on use may be necessary, though it may not be completely effective unless an international ban can be imposed.

(*f*) The principle of authorizing disposals, a key aspect of the control of radioactive waste disposal, is applicable to toxic waste disposal but to be effective and workable and realistic (i) there is an urgent need of more knowledge of the environmental behaviour of these wastes, so that wastes containing small concentrations can be exempted from the authorization procedure and so that conventional (and therefore cheap) methods of disposal may be used wherever practicable, and (ii) there must be an ultimate method of disposal available when normal methods of disposal cannot be authorized.