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SITE SELECTION CRITERIA FOR DUMPING GROUNDS

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INTRODUCTION

This paper was prepared in response to a request to ICES by the Joint Technical Working Group/Standing Advisory Committee on Scientific Advice (TWG/SACSA) Monitoring Group of the Oslo (OSCOM) and Interim Paris Commissions (IPARCOM) made at its meeting 12-14 January 1977 in Brussels. It was submitted to the mid-term meeting of ACMP in June 1977 and has been amended somewhat in the light of the comments at that meeting. In the discussion at the Joint TWG/SACSA Monitoring Group meeting of existing and proposed monitoring in the OSCOM/IPARCOM area by the signatory states, the Group decided that further information was needed for OSCOM with regard to criteria for the selection and monitoring of dumping sites.

Having reviewed the GESAMP report on criteria for the selection of dumping sites (1) and a four-part series of papers (2-5) submitted to various ICES Statutory Meetings, the authors came to the conclusion that the selection of an appropriate site for the dumping of wastes at sea depends basically on the type of waste or pollutant to be disposed of, and on the environmental and biological conditions on and around the proposed site. Nonetheless, the use which is made of the proposed sea area, or its potential for such use, in terms of amenities, fishing, dredging, etc., is an important factor to be taken into account when choosing a dumping site. Furthermore, it should be remembered that the marine option for the dumping of wastes is but one of a number of possible options; for example, land based disposal, or incineration; all of which must be weighed in terms of environmental, political, economic and logistic considerations before a final choice can be made.

As far as wastes are concerned, we may usefully divide these into three types: (1) those which mix completely with, and move as, the water mass (2) those which are particulate in nature and will settle to the bottom over an area dependent on the relative density of the particles, the current velocities, the stratification of the water column and turbulence induced by the wind or tidal streams (3) those which will essentially sink directly to the bottom and remain there, having a considerably higher density than sea water and being heavy enough or bulky enough to resist re-entrainment within the water column. Combinations of these types may also occur.

1. WASTES WHICH MIX COMPLETELY WITH SEA WATER

For pollutants which mix completely with sea water, the main aim is usually to ensure fast and complete mixing, accompanied by rapid dilution and dispersion. Thus in selecting a suitable site for this type of waste consideration must be given to finding an area with considerable turbulence, generally determined by wind, waves, current variability and possibly bottom topography, bearing in mind the damping effect caused by stratification. An area with fast transport away from the dump site, by residual currents, and towards areas which are not biologically sensitive would also be very desirable. In shallow sea areas on the continental shelf we may expect tidal streams to be particularly important in ensuring thorough mixing, hence areas of strong tidal currents should be chosen. Mixing can of course be hastened by suitable dispenser equipment discharging into the wake of vessels or attached to the ends of outfalls.

The chemical composition of wastes will also have a bearing on the selection of a suitable site. Especially, this is the case if the wastes are highly toxic, since clearly these should not be discharged into areas which are biologically sensitive. Toxic pollutants may inhibit the growth of (or in severe cases perhaps eliminate) fish, shellfish, planktonic and benthic organisms (particularly in the young stages) before a sufficient degree of dilution has been achieved, as well as causing serious damage, including tainting of the fish or shellfish. Initial dilution at the time of dumping is particularly important in this context.

Although dumping of mercury and cadmium is prohibited under Annex I to the Oslo Convention due to the special risks they pose to human health, other heavy metals and elements, arsenic, lead, copper and zinc, may be dumped after a special permit has been obtained. The chemical state of the metals is an important factor in their toxicity: certain valency states are more toxic than others and complexed or adsorbed metals are generally less available to marine organisms.

Another factor to be considered when the pollutant may affect the penetration of light through the water is the possible effect on productivity. Additionally, if the pollutant is highly coloured, and a discharge near the coast is being contemplated, the effect on local amenities must be weighed.

Thus, overall, for pollutants which mix rapidly with sea water, the most suitable sites for dumping are likely to be in areas away from coasts, which have rapid mixing due to strong tidal or wind induced currents and a significant residual current away from the dumping area which does not transport the pollutant towards any nearby region which has other uses likely to be affected by the pollutant. Clearly, the distance which that dump site would need to be from such an area would depend on the likely concentration of pollutant by the time it arrived at the sensitive area. Predictions would need to be made of the variation of concentration with time and distance using standard hydrographic techniques (viz tracers and current meters to measure dispersion and advection). The work of the ICES Study Group on Flushing Time of the North Sea (6) and earlier related work (7) is clearly relevant to the general problem of exchange rates. These reports conclude that the average flushing time of the North Sea as a whole is of the order of one year, and that such an average, as applied to the whole North Sea, is not particularly meaningful. The work of the Study Group is currently concerned with establishing a breakdown of the North Sea into regions which are reasonably consistent hydrographically and for which more meaningful flushing times can be estimated. In principle, there is considerable scope for the discharge of certain miscible pollutants into the Oslo Commission area provided sufficiently rapid dilution can be achieved. However, it should be recognised that the dilution which can be achieved in a confined area such as the North Sea (or more importantly, in specific parts of the North Sea), depends on the exchange rate or flushing time for that area.

2. PARTICULATE WASTES

Many of the aspects considered above will also apply to fine particulate wastes in that they may be transported considerable distances, depending on their density and hence sedimentation rate, before settling to the bottom. However, particulates will eventually settle to the bottom, the heavier ones relatively near to the dumping area, and hence will affect the sediment composition of the bottom. Leaving aside the possible chemical effects on benthic fauna and flora (1 and 2), the physical effect will be to alter the sediment grain size and consistency. Not only is this likely to change the benthic ecosystem in the area (not necessarily for the worse), it will also affect fisheries, where a particular spawning area or nursery area is dependent on a particular type of bottom, e.g. gravel beds on which herring spawn could be affected at a considerable distance from the dump site by the superposition of finer grained sediment; similarly rocky crevices required by lobsters could become covered by particulate material on, or at some distance from, a dump site.

A recent ICES study shows that, for the Oslo Commission area, nearly 75% of all waste dumped is dredge spoil, while sewage sludge accounts for about 12% (8). Both can be contaminated with bacteria and viruses, metals, organo-halogens, polynuclear aromatic hydrocarbons, and petroleum hydrocarbons. Clearly these wastes should not be dumped on such spawning or nursery areas, or indeed anywhere which has a residual current system which is likely to transport the finer particulates to a sensitive area, without a thorough evaluation of the consequences. It must be remembered that fine grain particulates will settle out to the bottom in areas where currents are weak, but may become re-entrained when the current exceeds the threshold for that particular grain size. Hence in areas of strong tidal streams, some sediments may be continually deposited and re-entrained, gradually being transported away on the residual current system, until they reach an area where the bottom current velocity is too weak to lift them from the bottom again.

Particularly important when large quantities of sludge are being dumped, is the possible building up of sludge banks and subsequent interference with navigation in estuarine areas (2). These are not normally ideal dumping areas and should be avoided as far as is practicable. It should be remembered that a compensation current normally flows upstream along the bottom in estuarine areas and can transport large quantities of muddy sediment back into the river. Obviously it is necessary to know beforehand of these likely sediment movements and this can be accomplished by a suitable research programme of current measurement and sediment tracking. Radio tracers are particularly convenient for this type of work.

The other major problem with sludge disposal, since there is a high organic content, is the biochemical oxygen demand (BOD) which can lead to deoxygenation of the water, or sediment, forming an anaerobic zone which is disastrous to the benthic community. This can be avoided, or at least minimised, by selecting the dumping zone in an area of rapid turbulent mixing i.e. since these areas are normally in shallow seas, in areas of rapid tidal mixing.

Thus, for particulate waste disposal, we must bear in mind the criteria for miscible pollutants in so far as the transport of fine particulates are concerned, but must also select an area away from compensation currents and coastal upwelling (onshore bottom currents), bearing in mind the effect on the benthic community, the BOD, and the possible navigational hazards. Preliminary research will usually be required as for miscible pollutants, but with particular emphasis on near bottom conditions, plus sediment sampling (type and grain size), measurement of sediment movements and sampling of the benthic community.

3. HEAVY AND BULKY WASTES

The selection of a site for the disposal of heavy and bulky wastes at sea tends to be an easier problem, in that it is clear where the waste is expected to stay. Areas to avoid are obviously those on which interference with trawling or navigation may be expected, or in the vicinity of pipelines and telephone cables etc, but it should be remembered that artificial reefs have been deliberately constructed in some areas in shallow seas (to dispose of old motor cars etc) with some success in attracting and concentrating fish. Thus an area of known poor fishing, and deep enough to avoid navigational hazards, which is also away from undersea pipelines and cables, might be a suitable disposal site for such waste materials. Deep holes in the sea floor, or at the bottom of enclosed basins, may also be suitable areas for disposal of inert material. However, generally it is preferable to avoid any area, and particularly the bottom of an enclosed basin, which contains stagnant water, since undesirable materials could be recycled to the more productive surface layers. Rolfe (3) has suggested that areas of infolding on the deep seafloor might be suitable for the disposal of some wastes, but current thinking among marine geologists and those responsible for planning the disposal of radioactive wastes in the deep ocean, is that these areas of tectonic plate convergence tend to be unpredictable and consequently are no longer thought of as suitable, for example, for the disposal of high-level, long-lived radioactive wastes.

4. BIOLOGICAL ASPECTS

The biological characteristics of the proposed site should also be assessed. The biological sensitivity should be evaluated in terms of whether the area supports high biological productivity, intensive fishing, breeding or nursery grounds, or migrating routes of important fish resources. Dumped materials have the potential to affect living resources in numerous ways. For instance, pollutants which are artificial stressors may affect the organisms' ability to adapt to natural changes. For migrating species, the presence of wastes could possibly interfere with their ability to find their home-spawning grounds. Wastes could also affect the spawning, nursery, and feeding processes of marine organisms.

The greatest concern should be given to those wastes which (i) are toxic to marine organiams, and/or (ii) are accumulated in organisms, and/or (iii) persist in the environment for long periods of time. With these points in mind, certain substances are listed in Annex I to the Oslo Convention because they were considered to be particularly hazardous to the marine environment and intentional dumping of them is therefore prohibited. Less hazardous wastes, e.g. sewage sludge and dredge spoils, may contain micro-organisms which could cause human diseases if returned to man, e.g. via food. Thus, the harvesting of shellfish near sludge or spoil dumping areas may need to be prohibited or controlled to protect human health. Toxicity studies should be done on waste materials to assess the risk to the most sensitive or most critical organisms in the area. Additionally, except perhaps for wastes which are dispersed in areas of rapid circulation, the sub-lethal, chronic effects of a waste on the organisms must be estimated.

The accumulation of pollutants in a waste by living organisms should also be investigated. Although bioaccumulation of a pollutant in an organism may not necessarily harm that particular organism, it could be harmful to its predator, which might thereby be exposed to significantly higher concentrations of this pollutant than occur in the normal environment. For example, mussels (*Mytilus* species) concentrate PCBs and DDT to a level up to 4 to 5 orders of magnitude greater than that occurring in sea water (9).

Sewage sludge can pose a health hazard by virtue of the pathogenic bacteria and viruses contained in it. While the bacterial content can be reduced by digestion and die away, only dilution after dumping will reduce the hazards of the viruses. Thus, dumping of sewage sludges must always be conducted carefully.

ICES has been collecting information for several years to determine more precisely the migration routes and spawning grounds of the important fish stocks in the north-east Atlantic, and clearly these spawning grounds and the associated nursery areas are biologically sensitive regions which must be carefully protected from contamination. Discussions of a few of these areas may be found in (10-24).

CONCLUSION

The area covered by the Oslo Commission has a finite capacity to accept the dumping of a large variety of different waste materials. However, certain criteria for the selection of wastes which can be dumped and sites where this may occur must be strictly observed. When such criteria, as listed in Annex III of the Convention and expanded upon in the GESAMP report (1) are fully considered, the impact of dumped wastes on the marine environment can be kept to a minimum.

Finally, it should be recognised that the selection of a particular site for the disposal of a specific pollutant will always need to be considered in the light of local conditions and knowledge. Research should be conducted before the final approval of the site whenever insufficient data already exist to satisfy the criteria outlined above, and adequate monitoring of conditions after the commencement of dumping should be envisaged, particularly of the biological and sedimentological parameters, for as long a period as proves necessary to validate the predictions made as to the effects on the local environment.

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