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MONITORING OF AREAS RECEIVING DUMPED WASTES AROUND ENGLAND AND WALES

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ABSTRACT

The effects of dumping wastes at sea from England and Wales are monitored as part of the controls under national legislation and the Oslo and London Conventions. This paper describes the objectives and methods of these monitoring surveys and presents the results of several surveys of sites where sewage sludge, dredged spoil and industrial wastes have been dumped.

INTRODUCTION

The United Kingdom controls the disposal of waste at sea by dumping from vessels through the Dumping at Sea (DAS) Act, 1974 and in accordance with the Oslo and London Conventions on the prevention of marine pollution from the dumping of wastes. Under these regulations the national licensing authorities apply controls at three levels:

(i) pre-discharge licensing of the waste including the manner and location of discharge, in accordance with the criteria of the DAS Act and the Conventions;

(ii) inspections of the loading or dumping of wastes by enforcement officers to ensure compliance with licence conditions;

(iii) post-discharge monitoring of areas used for the dumping of wastes to establish the actual effects of dumping.

The objectives of monitoring the areas, the determinands monitored, and results of the monitoring programmes carried out by the Ministry of Agriculture, Fisheries and Food (MAFF) off England and Wales are described in this paper. Full details of the objectives of MAFF's monitoring programmes have been published (Norton and Rolfe, 1978) together with the methods employed (Eagle *et al.*, 1978a). Reports on some of the major dumping areas have been published in the same series of publications

(Eagle et al., 1978b, 1979a and 1979b; Murray and Norton, 1979; Murray et al., 1980). Others are in press or preparation.

OBJECTIVES OF MONITORING

The general objectives of monitoring programmes carried out in support of the DAS Act are:

(i) to improve the basis on which licence applications are assessed, by increasing knowledge of field effects from large discharges;

(ii) to provide the necessary evidence to demonstrate within the international dumping conventions that the control measures applied are sufficient to ensure that the dispersive and assimilative capacities of the marine environment are not exceeded, so causing environmental damage.

These general objectives have been transformed into more specific objectives in the case of each disposal area where it is considered necessary to establish:

(i) the short, medium and long-term dispersal paths and fate of the waste and any persistent components it contains;

(ii) effects on the physical, chemical and microbiological characteristics of the receiving area attributable to dumping (including the effects on the quality of fish and shellfish and their food);

(iii) whether biological effects result from sludge dumping.

In the case of the third objective the main programmes relate to the effects that waste particles, associated chemicals and micro-organisms may have on the bottom living organisms (benthos). These animals are considered most suitable for study since they are relatively immobile and long-lived, so that their distribution and abundance in areas subject to physical and chemical changes due to the accumulation of dumped materials may reflect the influence of dumping over a relatively long preceding period.

DETERMINANDS MONITORED

Since many wastes may contain both particulate and soluble components, it if often necessary to consider the possibility of measurable effects in both the water column and at the sea bed. Consequently there are many measurements and techniques which may, in certain circumstances, be applicable to the monitoring of disposal areas. These include:

(i) At the sea bed:

sea bed topography via echo sounding, sonar scanning, photography, TV;

sediment composition, including particle size, metals, organics and bacterial analysis;

distribution of the benthos and analysis of the factors influencing their distribution;

chemical contamination of benthos, shellfish or demersal fish.

(ii) In the water column:

chemical quality of the receiving waters (including DO, nutrients, metals);

chemical and bacterial quality of fish;

hydrography, including measurement of surface and bottom currents and residual water movements.

Clearly, the routine measurement of all these parameters without prior consideration of the extent of existing knowledge, the nature and size of the dumping operation as well as other factors would be extremely wasteful of resources, and hence techniques are applied selectively. The exact nature of the survey depends on the dumping ground and the waste dumped, but generally a grid of grab stations is worked in order to obtain sediments and benthos. In addition, trawling is carried out in order to collect commercial fish, shellfish and epibenthos for analysis. These investigations may be supplemented by additional measurements or with information on the hydrography of the area under investigation, fish and shellfish stocks, location of spawning and nursery grounds and any other information that will allow as accurate a picture as possible to be formulated of the ecology and fisheries of the area. Comparison of the data obtained from various areas and at various times can then allow an assessment to be made of whether dumping is having an adverse effect.

EXTENT OF SURVEYS

A summary of the monitoring programmes of MAFF is given in Table 1 and the location of the dumping areas are shown in Figure 1. The types of areas surveyed are dumping grounds for sewage sludge, dredge spoil, colliery waste, fly ash and industrial waste. It should be noted that, although monitoring has been undertaken by MAFF since 1970, from 1975 significant changes have taken place in the detailed techniques used for sediment analysis and the interpretation of the benthos data.

These more recent surveys have employed detailed analysis of the sediment, for particle size, organic and trace metal contents of different size fractions and, where sewage sludge is being dumped, for bacteriological (E. coli and coliform) content. The benthos has also been identified to species level and its distribution analysed by classification and ordination techniques and compared statistically with that of various characteristics of the sediment affected by dumping. These 'intensive' quantitative surveys have replaced the qualitative 'rapid assessment' surveys described by White et al. (1974) and have been carried out at most of the active dumping areas, but in some areas the type of ground precludes their successful application.

EFFECTS OF DUMPING IDENTIFIED BY MONITORING

Sewage sludge and industrial waste

The possible effects of sewage sludge and industrial waste dumping on the marine environment depend upon the characteristics of the area, particularly those determining its capacity for dilution and dispersion. At one extreme where water movements are slight, dispersion is likely to be severely reduced and accumulation of sludge on the bottom may occur. In such cases effects are likely to be readily evident but restricted to a relatively small area. At the other end of the scale, water movements may be sufficiently strong to cause rapid dispersion such that little or none of the sludge reaches or remains on the bottom close to the dumping ground. In such cases the area of potential effect is greatly increased but effects over this larger area may be slight and difficult to determine. Thus the expected effects are likely to vary considerably between the areas concerned, and particularly with the size of the disposal operation.

In all the areas which receive sludge and which have been studied in detail it has been possible to identify some enrichment of the fine sediment fraction by organic matter and trace metals and, in some areas, in the coarse fraction of the sediment as well. The extent of enrichment varies considerably. In the areas receiving small quantities of sludge or where dispersion away from the dumping site is rapid, the elevations are slight, localised and may only be apparent for some chemical determinands. The Plymouth, Liverpool Bay, Humber and Nab areas are in this category. In other areas where there is good dispersion but the quantity dumped is very large, or where dispersion is poor, readily detectable and well defined zones of enrichment of carbon, metals and bacteria are found (e.g., Lyme Bay and Barrow Deep).

The effect of sewage sludge dumping on the benthos varies. In some areas, no effect is detectable with a quantitative analysis of the faunal data but in other areas the lack of identifiable effects may be due to the difficulty of quantitative sampling. In areas where ecological effects have been demonstrated, they are normally of a minor nature except where large accumulations of organic material have occurred. In Lyme Bay there was a slightly inhibitory effect on the benthos (as shown by a reduction in species richness) where organic and metal levels were elevated. In Liverpool Bay, a reduction of species diversity appeared to be associated with sludge disposal. In the Thames Estuary, the fauna appeared to be essentially determined by the natural substrate and hydrography. Areas of increased organic carbon in the sediment did not appear to lead to increases in abundance and were more often associated with reductions in the number of individuals and/or species. In the immediate dumping area however an abundant fauna dominated by suspension feeders was present suggesting the possible utilisation of sludge particles in suspension. None of these minor ecological changes are believed to affect significantly the productivity of the area from the fisheries viewpoint. The effects of sewage sludge dumping on water quality have been found to be transient. Turbidity is inevitably increased by dumping for a few hours after discharge. In the case of dissolved oxygen (DO), only in Liverpool Bay have levels of DO below 90% of saturation been recorded, and then only in bottom waters under conditions of thermal stratification. Detailed surveys of the water column for nutrients and metals were carried out in the Liverpool Bay area, the Thames Estuary and Spurn Head areas in 1978. Only in the Thames area which receives the largest quantity of sewage sludge (5×10^6 t a^{-1}) were the affects of dumping readily detectable above the generally elevated concentrations due to the proximity of the Estuary, thus tending to confirm the importance of nearby land-based sources in determining water quality in inshore coastal zones.

Monitoring of fish and shellfish quality shows that metal levels in samples taken from the vicinity of the larger dumping areas are higher than in offshore waters. This is a characteristic of all fish landed from inshore waters and the extent to which dumping contributes to these levels is difficult to estimate due to the incomplete knowledge of the relative quantities of metals entering an area from different sources, and the different effects the source may have on the metal's biological availability. The only case where dumping is believed to have been primarily responsible for a reduction in fish quality has been in the Outer Thames Estuary where, prior to tighter controls on sludge quality in 1974, concentrations of mercury in demersal fish were significantly elevated.

Solid waste disposal areas

Detailed studies of the effects of colliery waste and fly ash disposal have been carried out at four disposal areas off the north-east coast of England, which have received a total of 2.5 x 10^6 tonnes of waste each year for many years.

The main effect of dumping is a gross change in the sea bed from the original sediments (whether rock outcrops, gravels, sands, etc.) to sediments wholly or partly comprised of waste-derived materials. Although the majority of the waste remains on the sea bed close to the point of dumping, fine particles have been shown to be widely distributed both by movement as bedload and in suspension.

In the areas where deposition is frequent, severe depletion of the benthos has been found to occur and at some stations in the centre of the area of dumping benthic productivity was near zero. Both species diversity and abundance increased as the amount of waste in the sediment decreased and detectable effects generally were limited to the area in which initial settlement of the waste occurred. Because of the quantity of waste involved and the long period over which dumping has occurred (pre-dating the controls of the Dumping at Sea Act), quite large areas of the sea bed have been affected, totalling approximately 40 km^2 for the four areas concerned. Within these areas benthic productivity has been significantly reduced and the potential for trawling and potting also reduced due to physical obstructions at the sea bed.

Dredge spoil disposal areas

Only limited studies of areas used for the disposal of dredge spoils have been carried out. However, these have demonstrated that where capital spoils or heavily contaminated spoils are dumped, it can result in severe depletion of the benthos in the dumping area, as occurs with other solid wastes already described (Murray and Norton, 1979), as well as in direct interference with trawling or potting. Such effects are not usually associated with maintenance dredgings.

CONCLUSIONS

Monitoring of waste disposal areas off England and Wales in recent years has allowed the dispersal paths and fate of the main components of the wastes to be determined and the effects on the benthos to be identified. Due to the use of detailed and quantitative sedimentological and ecological techniques, effects have been identified with a greater degree of confidence than in earlier work.

The most significant biological effects are found on the benthos in solid waste and some dredge spoil disposal areas where frequent dumping and accumulation of the waste on the sea bed leads to local but severe depletion of the benthos as well as interference with trawling or potting. By contrast, the effects identified in sewage sludge and industrial waste disposal areas are of a minor ecological nature which are unlikely to affect fisheries or their productivity.

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Table 1 Location and types of monitoring employed at dumping areas used for the disposal of wastes

Area	Co-ordinates		Type and quantity of waste disposal (10^6 t a^{-1})	Techniques employed in monitoring*
Blyth	55°07'24"N 55 07 42 55 06 40 55 05 58 55 04 44	01°23'42"W 01 22 03 01 23 33 01 23 12 01 21 34	Colliery waste (.3) Fly Ash (.6) Dredgings (.3)	1 2 4 6 +7 8
Tyne	54°59.7'N 54 58.0 54 56.9 and ¼ mile offshore	01°16.7'W 01 15.8 01 15.8	Colliery waste (.6) Fly Ash (.2) Dredgings (.2)	1 2 4 5 6 7 8 9 10
Wear	54°55.6'N 54 55.6 54 54.7 54 54.7	01°18.0'W 01 17.5 01 17.5 01 18.0	Colliery waste (.8) Dredgings (.5)	1 2 4 5 6 +7 8
Tees	54°40'47"N 54 41 02 54 41 31 54 40 13	01°03'29"W 01 00 16 01 02 14 01 00 30	Dredgings (3.0)	1 2 4 6 7 8
Spurn Head (Humber)	Between 53°30'N 00 30 E	53°35'N 00 35 E	Sewage sludge (.4) Industrial wastes (.05)	1 2 4 5 6 7 8 9 10
Roughs Tower	51°52'45"N 51 52 12 51 51 18 51 51 56	01°29'29"E 01 31 39 01 31 06 01 28 57	Dredgings (.4) Sewage sludge (.25)	1 2 3 4 6 7 8 9
Thames	51°41'15"N 51 40 45 51 49 13 51 39 44	01°18'42"E 01 20 18 01 17 21 01 17 57	Sewage sludge (5)	1 2 3 4 5 6 +7 8
South Falls	51°35'N 51 35 51 30 51 30	01°58'E 02 00 02 00 01 57	Industrial wastes (.05)	6 8
Nab Tower	50°36'57"N 50 36 06 50 34 04 50 35 00	00°56'09"W 00 55 00 58 33 00 59 48	Dredgings (.3) Sewage sludge (.3) Industrial wastes (.01)	1 2 4 5 6 7 8 9
Exeter (Lyme Bay)	50°27' N 50 32.5 50 28 50 22.5	03°20.8'W 03 01.8 03 02.5 03 19.1	Sewage sludge (.07)	1 2 3 4 5 6 +7 8 9

Table 1 (continued)

Area	Co-ordinates		Type and quantity of waste disposal (10^6 t a^{-1})	Techniques employed in monitoring*
Plymouth	50°14.9'N 50 13.5 50 15.5 50 14.0	04°07.5'W 04 07.5 04 12.5 04 12.5	Sewage sludge (.1)	1 2 3 6 +7 8
Bristol Channel	Within 1 mile of 51°24.5'N	 04°04'W	Sewage sludge (.4) Industrial wastes (.01)	1 2 4 6 7 8 10
Liverpool Bay	Between 53°30'N 03 34.0 W	 53°35.5'N 3 36.5 W	Sewage sludge (1.8) Industrial wastes (.25)	1 2 3 6 +7 8 9 10

* Number key

1. Physical analysis of sediments.
2. Chemical analysis of sediments.
3. Microbiological examination of sediments.
4. Observations of the sea bed with side scan sonar.
5. Observations of the sea bed with underwater camera.
6. Identification and enumeration of benthic animals. (+ signifies that the benthos have been sampled quantitatively and the resulting data analysed by multivariate statistical techniques).
7. Chemical analysis of selected benthic species.
8. Measurement of chemical quality of fish and shellfish.
9. Hydrographic studies with current meters.
10. Hydrographic studies with sea-bed drifter releases.

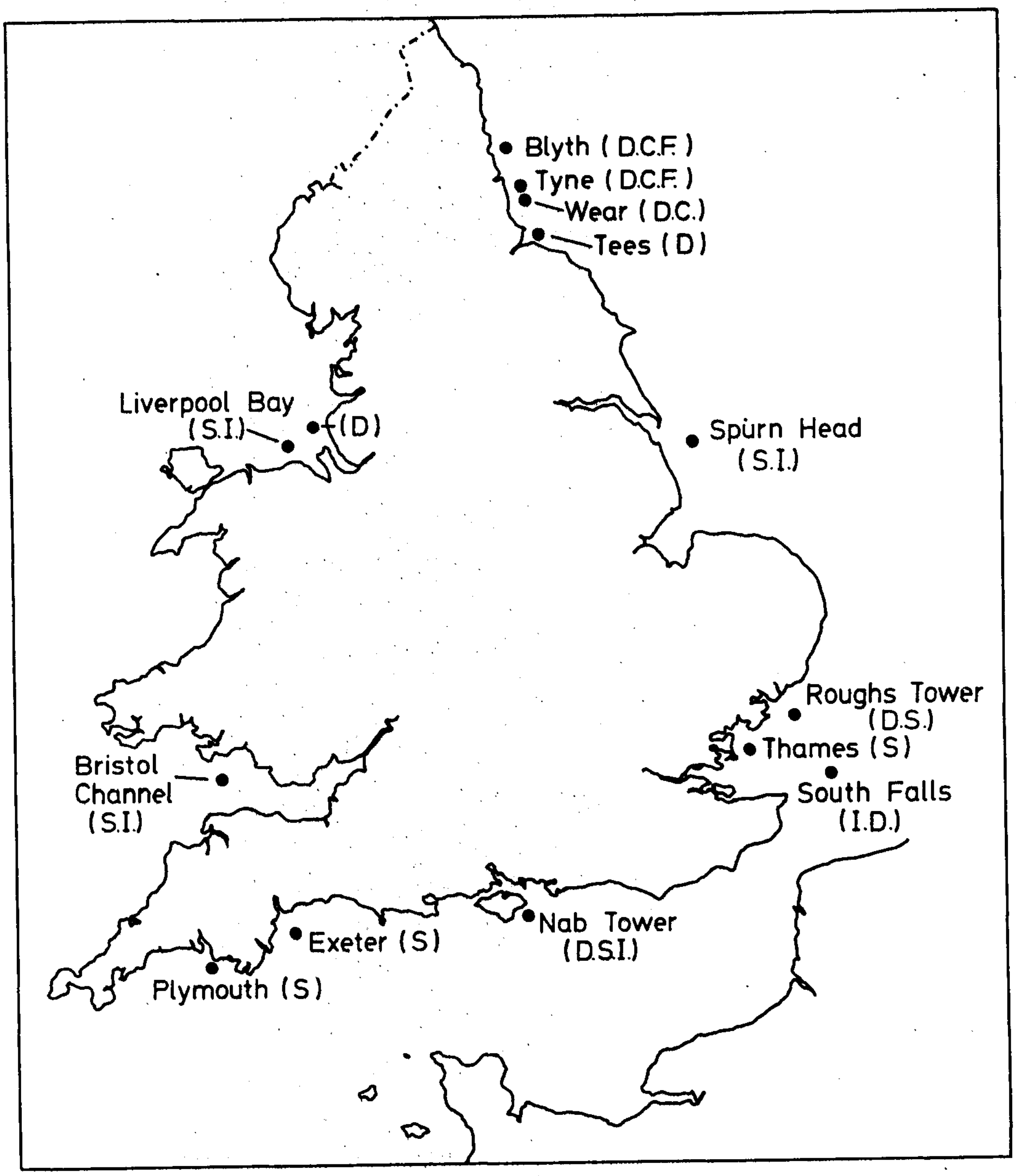

Figure 1 Position of dumping grounds which have been monitored by MAFF surveys 1970-1979.

C = colliery waste; D = dredgings; P = fly ash; I = industrial waste; S = sewage sludge.