ANNEX 43
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OSPAR Guidelines for the Management of Dredged Material

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OSPAR GUIDELINES FOR THE MANAGEMENT OF DREDGED MATERIAL

PREFACE

These guidelines were adopted at the 1998 Ministerial Meeting of the OSPAR Commission. Contracting Parties are obliged to take these guidelines into consideration in their authorisation or regulation procedures for dredged material. It will, however, be implicit that the detailed procedures described in the guidelines will not be applicable in all national or local circumstances.

1. INTRODUCTION

1.1 Dredging is essential to maintain navigation in ports and harbours as well as for the development of port facilities. Much of the material removed during these necessary activities requires disposal at sea. Most of the material dredged from within the OSPAR maritime area is, by its nature, either uncontaminated or only slightly contaminated by human activity (i.e. at, or close to, natural background levels). However, a smaller proportion of dredged material is contaminated to an extent that major environmental constraints need to be applied when depositing these sediments.

1.2 Within the framework of the Convention for the Protection of the Marine Environment of the North-East Atlantic (hereinafter called the 1992 OSPAR Convention), dredged materials have been listed in Article 3.2 of Annex II as being permitted to be dumped at sea.

2. SCOPE

2.1 The guidelines are designed to assist Contracting Parties in the management of dredged material in ways that will prevent and eliminate pollution and thus protect the maritime area. In accordance with the mandate of the OSPAR Commission, the guidelines specifically address the disposal of dredged material by dumping in the maritime area.

2.2 It is recognised that both removal and disposal of dredged sediments may cause harm to the marine environment, but removal by dredging is not covered by the 1992 OSPAR Convention. Nevertheless, Contracting Parties are encouraged to exercise control over both dredging operations, including sidecast and agitation dredging practices and disposal operations using a Best Environmental Practice (BEP) approach designed to minimise both the quantity of material that has to be dredged and the impact of the dredging and disposal activities in the maritime area - see Technical Annex III. Advice on environmentally acceptable dredging techniques is available from a number of international organisations e.g. the Permanent International Association of Navigation Congresses (PIANC).

2.3 In the context of these guidelines, dredged materials are deemed to be sediments or rocks with associated water, organic matter etc. removed from areas that are normally or regularly covered by water, using dredging or other excavation equipment.

2.4 The terms "dumping" and "disposal" are used in accordance with Article I (f) and (g) of the 1992 OSPAR Convention.

3. REQUIREMENTS OF THE 1992 OSPAR CONVENTION [1]

3.1 Article 2.1a requires Contracting Parties to take all possible steps to prevent and eliminate pollution and to take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected.

3.2 Article 4 requires Contracting Parties to take all possible steps to prevent and eliminate pollution by dumping or incineration of wastes or other matter in accordance with the provisions of the 1992 OSPAR Convention, in particular as provided for in Annex II.

3.3 With regard to the dumping of wastes or other matter at sea that are permitted under Article 3(2) of Annex II of the 1992 OSPAR Convention, Article 4 (1)(a) of Annex II requires Contracting Parties to ensure that no such materials are dumped without authorisation or regulation by their competent authorities. In addition, Article 4 (1)(b) of Annex II requires Contracting Parties to ensure that such authorisation or regulation is in accordance with the relevant applicable criteria, guidelines and procedures adopted by the Commission.

3.4 Furthermore, Article 4 (3) of Annex II requires Contracting Parties to keep records and report to the Commission on the nature and quantities of wastes or other matter dumped at sea in accordance with Article 4(1) of Annex II and the locations and methods of dumping used. To this end, OSPAR has agreed on reporting formats for the submission of data on wastes dumped at sea.

4. EVALUATION OF NEED FOR DREDGING AND DISPOSAL

4.1 There are a number of dredging activities which may give rise to the need to dispose of sediments. These include:

a. Capital dredging - for navigation, to enlarge or deepen existing channel and port areas or to create new ones; and for engineering purposes; e.g. trenches for pipes, cables and immersed tube tunnels, removal of material unsuitable for foundations, removal of overburden for aggregate extraction;

b. Maintenance dredging - to ensure that channels, berths or construction works are maintained at their designed dimensions (i.e. counteracting sedimentation and changes in morphology); and

c. Clean-up dredging - deliberate removal of contaminated material from the marine environment for human health and environmental protection purposes.

4.2 Before beginning a full assessment of the material and the disposal options the question should be asked "Is dredging necessary?". In the event of a subsequent full assessment indicating no acceptable options for disposal it will be necessary to re-address this question in a broader context.

4.3 In addition, attention needs to be given to ensuring that the quantities of material needing to be dredged and disposed of at sea are minimised as far as is practicable. This is dealt with further in Technical Annex III under 'Optimise the disposed quantities'.

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1 All Article or Annex references mentioned in this chapter refer to the 1992 OSPAR Convention.

5. DREDGED MATERIAL CHARACTERISATION

5.1 Guidance on the selection of determinants and methods of contaminant analysis, together with procedures to be used for normalisation and quality assurance purposes, will be found in the Technical Annexes. It is envisaged that developments in biological testing techniques might eventually provide sufficient information to assess the potential impact of the contaminants in the material, so that less reliance would need to be placed on chemical testing.

Exemptions from detailed characterisation

5.2 Dredged material may be exempted from the testing referred to in paragraphs 5.4 to 5.9 of these Guidelines (but note that the information listed in paragraph 5.3 below will still be required) if any of the criteria below are met:

a. it is composed of previously undisturbed geological material; or

b. it is composed almost exclusively of sand, gravel or rock; or

c. in the absence of appreciable pollution sources, which should be supported by existing local information so as to provide reasonable assurance that the dredged material has not been contaminated, the quantity of dredged material from single dredging operations does not exceed 10 000 tonnes per year.

Dredged material that does not meet one of these requirements will need further stepwise characterisation to assess its potential impact (i.e. see paragraphs 5.3-5.9).

Physical characterisation

5.3 The following information is required:

a. the amount of material;

b. anticipated or actual loading rate of material at the disposal site;

c. sediment characteristics (i.e. clay/silt/sand/gravel/boulder) on the basis of visual determination.

Evaluation of the physical characteristics of sediments for disposal is necessary to determine potential impacts and the need for subsequent chemical and/or biological testing (cf. Technical Annex I for further guidance).

Chemical characterisation

5.4 Sufficient information for chemical characterisation may be available from existing sources. In such cases new measurements may not be required of the potential impact of similar material in the vicinity, provided that this information is still reliable and has been obtained within the last 5 years. Details of the substances recommended to be determined are listed in Technical Annex I.

5.5 Considerations for additional chemical characterisation of dredged material are as follows:

a. major geochemical characteristics of the sediment including redox status;

b. potential routes by which contaminants could reasonably have been introduced to the sediments;

c. industrial and municipal waste discharges (past and present);

d. probability of contamination from agricultural and urban surface runoff;

e. spills of contaminants in the area to be dredged;

f. source and prior use of dredged materials (e.g., beach nourishment); and

g. natural deposits of minerals and other natural substances.

5.6 Further information may also be useful in interpreting the results of chemical testing (cf. Technical Annex I).

Biological characterisation

5.7 If the potential impacts of the dredged material to be dumped cannot be adequately assessed on the basis of the chemical and physical characterisation and available biological information, biological testing should be conducted. Further detailed guidance on biological testing is provided in Technical Annex I.

5.8 It is important to ascertain whether adequate scientific information exists on the characteristics and composition of the material to be dumped and on the potential impacts on marine life and human health. In this context, it is important to consider information about species known to occur in the area of the disposal site and the effects of the material to be dumped and of its constituents on organisms.

5.9 Biological tests should incorporate species that are considered appropriately sensitive and representative and should determine, where appropriate.

a. acute toxicity;

b. chronic toxicity;

c. the potential for bioaccumulation; and

d. the potential for tainting.

Action List

5.10 The Action List is used as a screening mechanism for assessing properties and constituents of dredged material with a set of criteria for specific substances. It should be used for dredged material management decisions, including the identification and development of source control measures as described in paragraphs 6.1 to 6.3 below. The criteria should reflect experience gained relating to the potential effects on human health or the marine environment.

5.11 Action List levels should be developed on a national or regional basis and might be set on the basis of concentration limits, biological responses, environmental quality standards, flux considerations or other reference values. They should be derived from studies of sediments that have similar geochemical properties to those from the ones to be dredged and/or to those of the receiving system. Thus, depending upon natural variation in sediment geochemistry, it may be necessary to develop individual sets of criteria for each area in which dredging or disposal is conducted. With a view to evaluating the possibilities for harmonising or consolidating the criteria referred to above, Contracting Parties are requested to inform the OSPAR Commission through SEBA of the criteria adopted, as well as the scientific basis for the development and refinement of these criteria.

5.12 An Action List may include an upper and lower level giving these possible actions:

a. material which contains specified contaminants or which causes e.g. biological responses, in excess of the relevant upper levels should generally be considered unsuitable for disposal at sea;

b. material which contains specified contaminants or which causes e.g. biological responses, below the relevant lower levels should generally be considered of little environmental concern for disposal at sea; and

c. material of intermediate quality should require more detailed assessment before suitability for disposal at sea can be determined.

5.13 If dredged material is disposed of at sea when one or more criteria exceed the upper level, a Contracting Party should:

a. where appropriate, identify and develop source control measures with a view to meeting the criteria - see paragraphs 6.1 - 6.2 below; and

b. utilise disposal management techniques, including the use of containment or treatment methods, to mitigate the impact of the dumping operation on the marine environment see paragraphs 8.3 - 8.4 below; and

c. report the fact to the Secretariat, including the reason for permitting the disposal, in accordance with the requirements of section 1b (i) of the format for the Annual Reporting of Dumping Permits Issued.

6. CONTAMINANT SOURCE EVALUATION AND CONTROL

6.1 Contamination of estuarine and coastal marine sediments both as a consequence of historical and present day inputs presents a continuing problem for the management of dredged material. High priority should be given to the identification of sources, reduction and prevention of further contamination of sediments and should address both point and diffuse sources. Successful implementation of prevention strategies will require collaboration among national agencies with responsibility for the control of point and diffuse sources of contamination.

6.2 In developing and implementing the source control strategy, appropriate agencies should take into account:

a. the continuing need for dredging;

b. the hazards posed by contaminants and the relative contributions of the individual sources to these hazards;

c. existing source control programmes and other regulations or legal requirements;

d. the criteria for best available techniques (BAT) and best environmental practice (BEP) as defined in Appendix 1 of the 1992 OSPAR Convention, *inter alia*, as regards the technical and economic feasibility;

e. the evaluation of the effectiveness of measures taken; and

f. consequences of not implementing contaminant reduction.

6.3 In cases where there has been historical contamination or where control measures are not fully effective in reducing contamination to acceptable levels, disposal management techniques, including the use of containment or treatment methods may be required - see paragraphs 8.3 - 8.4 below.

7. DREDGED MATERIAL SAMPLING

Sampling for the purpose of issuing a dumping permit

7.1 Dredged material that is not exempted under paragraph 5.2 will require analysis and testing (cf. Technical Annex I) to obtain sufficient information for permitting purposes. Judgement and knowledge of local conditions will be essential when deciding what information is relevant to any particular operation .

7.2 A survey of the area to be dredged should be carried out. The distribution and depth of sampling should reflect the size and depth of the area to be dredged, the amount to be dredged and the expected variability in the horizontal and vertical distribution of contaminants. Core samples should be taken where the depth of dredging and expected vertical distribution of contaminants suggest that this is warranted. In other circumstances, grab sampling will usually be sufficient. Sampling from dumping vessels or barges is not advisable for permitting purposes.

7.3 The following table gives an indication of the number of separate sampling stations required to obtain representative results, assuming a reasonably uniform sediment in the area to be dredged:

Amount dredged (m3)	Number of Stations
Up to 25 000	3
25 000 - 100 000	4 - 6
100 000 - 500 000	7 - 15
500 000 - 2 000 000	16 - 30
>2 000 000	extra 10 per million m3

The number of sample stations can also be determined on the basis of the area to be dredged. The number of sample stations should take account of the exchange characteristics of the area; more samples may be required in enclosed and semi-enclosed areas and less in open areas.

7.4 Normally, the samples from each sampling station should be analysed separately. However, if the sediment is clearly homogenous with respect to sediment texture, it may be possible to analyse composite samples from two or more adjacent sampling stations at a time, providing care is taken to ensure that the results allow derivation of valid mean contaminant values. The original individual samples should, however, be retained until the permitting procedure has been completed, in case further analyses are necessary.

Frequency of sampling

7.5 If the results of the analyses indicate that the material is essentially 'clean', sampling in the same area need not be repeated more frequently than once every 3 years, provided that there is no indication that the quality of the material has deteriorated.

7.6 It may be possible, following assessment of the results of an initial survey, to reduce either the number of sampling stations or the number of determinants and still provide sufficient information for permitting purposes. If a reduced sampling programme does not confirm the earlier analyses, the full survey should be repeated. If the list of determinants is reduced, further analysis of the complete list of determinants is advisable every 5 years.

7.7 In areas where there is a tendency for sediments to exhibit high levels of contamination, analysis of all the relevant determinants should be frequent and linked to the permit renewal procedure.

8. EVALUATION OF DISPOSAL OP TIONS

8.1 The results of the physical/chemical/biological characterisation will indicate whether the dredged material, in principle, is suitable for disposal at sea. Where sea disposal is identified as an acceptable option, it is nonetheless important, recognising

the potential value of dredged material as a resource, to consider the availability of beneficial uses.

Beneficial Uses

8.2 There is a wide variety of beneficial uses depending on the physical and chemical characteristics of the material. Generally, a characterisation carried out in accordance with these guidelines will be sufficient to match a material to possible uses such as:

a. Engineered uses - land creation and improvement, beach nourishment, offshore berms, capping material and fill;

b. Agricultural and product uses - aquaculture, construction material, liners; and

c. Environmental enhancement - restoration and establishment of wetlands, terrestrial habitats, nesting islands, and fisheries.

The technical aspects of beneficial uses are well-established and described in the literature - see the references section.

Options for material for which criteria exceed the upper level

8.3 Where the characteristics of' the dredged material are such that normal sea disposal would not meet the requirements of the 1992 OSPAR Convention, treatment or other management options should be considered. These options can be used to reduce or control impacts to a level that will not constitute an unacceptable risk to human health, or harm living resources, damage amenities or interfere with legitimate uses of the sea.

8.4 Treatment, such as separation of contaminated fractions, may make the material suitable for a beneficial use and should be considered before opting for sea disposal. Disposal management techniques may include placement on or burial in the sea floor followed by clean sediment capping, utilisation of geochemical interactions and transformations of substances in dredged material when combined with sea water or bottom sediment, selection of special sites such as abiotic zones, or methods of containing dredged material in a stable manner. Advice on dealing with contaminated dredged material is available from PIANC- see references.

9. SEA DISPOSAL SITE SELECTION

9.1 The selection of a site for sea disposal involves considerations of an environmental nature and also economic and operational feasibility. Site selection should try to ensure that the disposal of dredged material does not interfere with, or devalue, legitimate commercial and economic uses of the marine environment nor produce undesirable effects on vulnerable marine ecosystems.

9.2 For the evaluation of a sea disposal site information should be obtained on the following, as appropriate:

a. the physical, chemical and biological characteristics ofthe seabed (e.g., topography, redox status, benthic biota);

b. the physical, chemical and biological characteristics of the water column (e.g., hydrodynamics, dissolved oxygen, pelagic species); and

c. proximity to:

(i) areas of natural beauty or significant cultural or historical importance;.

(ii) areas of specific scientific or biological importance;

(iii) recreational areas;

(iv) subsistence, commercial and sport fishing areas;

(v) spawning, recruitment and nursery areas;

(vi) migration routes of marine organisms;

(vii) shipping lanes;

(viii) military exercise zones;

(ix) engineering uses of the sea such as undersea cables, pipelines, etc.

Such information can be obtained from existing sources, complemented by field work where necessary.

9.3 The information on the characteristics of the sea disposal site referred to above is required to determine the probable fate and effects of the dumped material. The physical conditions in the vicinity of the sea disposal site will determine the transport and fate of the dredged material. The physico-chemical conditions can be used to assess the mobility and bioavailability of the chemical constituents of the material. The nature and distribution of the biological community and the proximity of the site of sea disposal to marine resources and amenities will, in turn, define the nature of the effects that are to be expected. Careful evaluation will allow determination of environmental processes that may dominate the transport of material away from the sea disposal site. The influence of these processes may be reduced through the imposition of permit conditions.

9.4 In some cases, dumping can augment existing effects attributable to inputs of contaminants to coastal areas through land runoff and discharge, from the atmosphere, resource exploitation and maritime transport. These existing stresses on biological communities should be considered as part of the assessment of potential impacts caused by dumping. The proposed method of dumping and potential future uses of resources and amenities in the marine receiving area should also be taken into account.

9.5 Information from baseline and monitoring studies at already established dumping sites will be important in the evaluation of any new dumping activity at the same site or nearby.

9.6 The use of open-sea sites at distant off-shore locations is seldom an environmentally desirable solution to the prevention of marine pollution by contaminated dredged material.

10. ASSESSMENT OF POTENTIAL EFFECTS

General

10.1 Assessment of potential effects should lead to a concise statement of the expected consequences of the disposal option (i.e., the Impact Hypothesis). Its purpose is to provide a basis for deciding whether to approve or reject the proposed disposal option and for defining environmental monitoring requirements.

10.2 This assessment should integrate information on the characteristics of the dredged material and the proposed disposal site conditions. It should comprise a summary of the potential effects on human health, living resources, amenities and other legitimate uses of the sea and should define the nature, temporal and spatial scales and duration of expected impacts based on reasonably pessimistic assumptions.

10.3 In order to develop the hypothesis, it may be necessary to conduct a baseline survey which describes not only the environmental characteristics, but also the

variability of the environment. It may be helpful to develop sediment transport, hydrodynamic and other models, to determine possible effects of disposal.

10.4 For a retentive site, where the material deposited will remain within the vicinity of the site, the assessment should delineate the area that will be substantially altered by the presence of the deposited material and what the severity of these alterations might be. At the extreme, this may include an assumption that the immediate receiving area is entirely smothered. In such a case, the likely timescale of recovery or re-colonisation should be projected after disposal operations have been completed as well as the likelihood that re-colonisation will be similar to, or different from, the existing benthic community structure. The assessment should specify the likelihood and scale of residual impacts outside the primary zone.

10.5 In the case of a dispersive site, the assessment should include a definition of the area likely to be altered inthe shorter term by the proposed disposal operation (i.e., the near-field) and the severity of associated changes in that immediate receiving environment. It should also specify the likely extent of long-term transport of material from this area and what this flux represents in relation to existing transport fluxes in the area, thereby permitting a statement regarding the likely scale and severity of effects in the long-term and far-field.

Nature of the impact

10.6 All dredged materials have a significant physical impact at the point of disposal. This impact includes covering of the seabed and local increases in suspended solids levels. Physical impact may also result from the subsequent transport, particularly of the finer fractions, by wave and tidal action and residual current movements.

10.7 Biological consequences of these physical impacts include smothering of benthic organisms in the dumping area. In comparatively rare circumstances, the physical impacts can also interfere with the migration of fish (e.g. the impact of high levels of turbidity on salmonids in estuarine areas) or crustacea (e.g. if deposition occurs in the coastal migration path of crabs).

10.8 The toxicological and bioaccumulation effects of' dredged material constituents should be assessed. Disposal of sediments with low levels of contamination is not devoid of environmental risk and requires consideration of the fate and effects of dredged material and its constituents. Substances in dredged material may undergo physical, chemical and biochemical changes when entering the marine environment and these changes should be considered in the light of the eventual fate and potential effects of the material. It should also be taken into account that disposal at sea of certain substances may disrupt the sensory capabilities of the fish and may mask natural characteristics of sea water or tributary streams, thus confusing migratory species which e.g. fail to find spawning grounds or food.

10.9 In relatively enclosed waters, such as some estuarine and fjordic situations, sediments with a high chemical or biological oxygen demand (e.g. organic carbon-rich) could adversely affect the oxygen regime of the receiving environment while sediments with high levels of nutrients could significantly affect the nutrient flux.

10.10 An important consequence of the physical presence of dredged material disposal activities is interference with fishery activities and in some instances with navigation and recreation. These problems can be aggravated if the sediment characteristics of the dredged material are very dissimilar to that of the ambient sediment or if the dredged material is contaminated with bulky harbour debris such as wooden beams, scrap metal, pieces of cable etc.

10.11 Particular attention should be given to dredged material containing significant amounts of oil or other substances that have a tendency to float following re-suspension in the water column. Such materials should not be dumped in a manner or at a location which may lead to interference with fishing, shipping, amenities or other beneficial uses of the marine environment.

11. PERMIT ISSUE

11.1 If sea disposal is the selected option, then a permit authorising sea disposal must be issued in advance. In granting a permit, the immediate impact of dredged material occurring within the boundaries of the disposal site such as alterations to the local, physical, chemical and biological environment is accepted by the permitting authority. Notwithstanding these consequences, the conditions under which a permit for sea disposal is issued should be such that environmental change beyond the boundaries of the disposal site are as far below the limits of allowable environmental change as practicable. The disposal operation should be permitted subject to conditions which further ensure that environmental disturbance and detriment are minimised and benefits maximised.

11.2 The permit is an important tool for managing sea disposal of dredged material and will contain the terms and conditions under which sea disposal may take place as well as provide a framework for assessing and ensuring compliance.

11.3 Permit conditions should be drafted in plain and unambiguous language and will be designed to ensure that:

a. only those materials which have been characterised and found acceptable for sea disposal, based on the impact assessment, are dumped;

b. the material is disposed of at the selected disposal site;

c. any necessary disposal management techniques identified during the impact analysis are carried out; and

d. any monitoring requirements are fulfilled and the results reported to the permitting authority.

Management of the Disposal Operation

11.4 Where appropriate, disposal vessels should be equipped with accurate positioning systems. Disposal vessels and operations should be inspected regularly to ensure that the conditions of the disposal permit are being complied with and that the crew are aware of their responsibilities under the permit. Ships' records and automatic monitoring and display devices (e.g. black-boxes), where these have been fitted, should be inspected to ensure that disposal is taking place at the specified disposal site.

11.5 This section deals with management techniques to minimise the physical effects of dredged material disposal. The key to management lies in careful site selection and an assessment of the potential for conflict with other interests and activities. In addition, appropriate methods of dredging and of disposal should be chosen in order to minimise the environmental effects. Guidance is given in Technical Annex III.

11.6 In most cases, blanketing of a comparatively small area of seabed is considered to be an acceptable environmental consequence of disposal. To avoid excessive degradation of the seabed as a whole, the number of sites should be limited as far as possible and each site should be used to the maximum extent that will not interfere with navigation.

11.7 Effects can be minimised by ensuring that, as far as possible, the dredged material and the sediments in the receiving area are similar. Locally, impacts may also be reduced if the deposition area is subject to natural physical disturbance. In areas where natural dispersion is low or unlikely to be significant and where reasonably clean, finer-grained dredged material is concerned, it may be appropriate to use a deliberately dispersive disposal strategy to prevent or reduce blanketing, particularly of a smaller site.

11.8 The rate of deposition of dredged material can be an important consideration since it will often have a strong influence on the impacts at the disposal site. It may therefore need to be controlled to ensure that the environmental management objectives for the site are not exceeded.

11.9 The infilling of depressions, deliberate capping or other contained methods of disposal of dredged material deposits may be appropriate in certain circumstances to avoid interference with fishing or other legitimate activities.

11.10 Temporal restrictions on dumping activities may be appropriate e.g. tidal and/or seasonal restrictions to prevent interference with migration, spawning or seasonal fishing activity. Silt screens have been used to reduce the impact of suspended solids levels outside working areas in estuaries in order to mitigate the impact of disposal on migratory fish. However, these have proved hard to manage effectively.

12. MONITORING

12.1 Monitoring in relation to disposal of dredged material is defined as measurements of compliance with permit requirements and of the condition and changes in condition of the receiving area to assess the Impact Hypothesis upon which the issue of a disposal permit was approved.

12.2 The effects of dredged material disposal are likely to be similar in many areas, and it would be very difficult to justify (on scientific or economic grounds) monitoring all sites, particularly those receiving small quantities of dredged material. It is therefore more appropriate, and cost effective, to concentrate on detailed investigations at a few carefully chosen sites (e.g. those subject to large inputs of dredged material) to obtain a better understanding of processes and effects.

12.3 It may usually be assumed that suitable specifications of existing (pre-disposal) conditions in the receiving area are already contained in the application for disposal

12.4 The impact Hypothesis forms the basis for defining the monitoring programme. The measurement programme should be designed to ascertain that changes in the receiving environment are within those predicted. In designing a monitoring programme the following questions must be answered:

a. what testable hypotheses can be derived from the Impact Hypothesis?

b. what measurements (e.g. type, location, frequency, performance requirements) are required to test these hypotheses?

c. what should be the temporal and spatial scale of measurements?

d. how should the data be managed and interpreted?

12.5 The permitting authority is encouraged to take account of relevant research information in the design and modification of monitoring programmes. Measurements should be designed to determine two things:

a. whether the zone of impact differs from that projected; and

b. whether the extent of change protected outside the zone of impact is within the scale predicted.

The first of these questions can be answered by designing a sequence of measurements in space and time that circumscribe the projected zone of impact to ensure that the projected spatial scale of change is not exceeded. The second question can be answered by the acquisition of measurements that provide information on the extent of change that occurs outside the zone of impact after the disposal operation. Frequently, this latter suite of measurements will only be able to be based on a null hypothesis - that no significant change can be detected.

Feedback

12.6 Information gained from field monitoring, (or other related research studies) can be used to:

a. modify or terminate the field monitoring programme;

b. modify or revoke the permit; and

c. refine the basis on which applications to dump dredged material at sea are assessed.

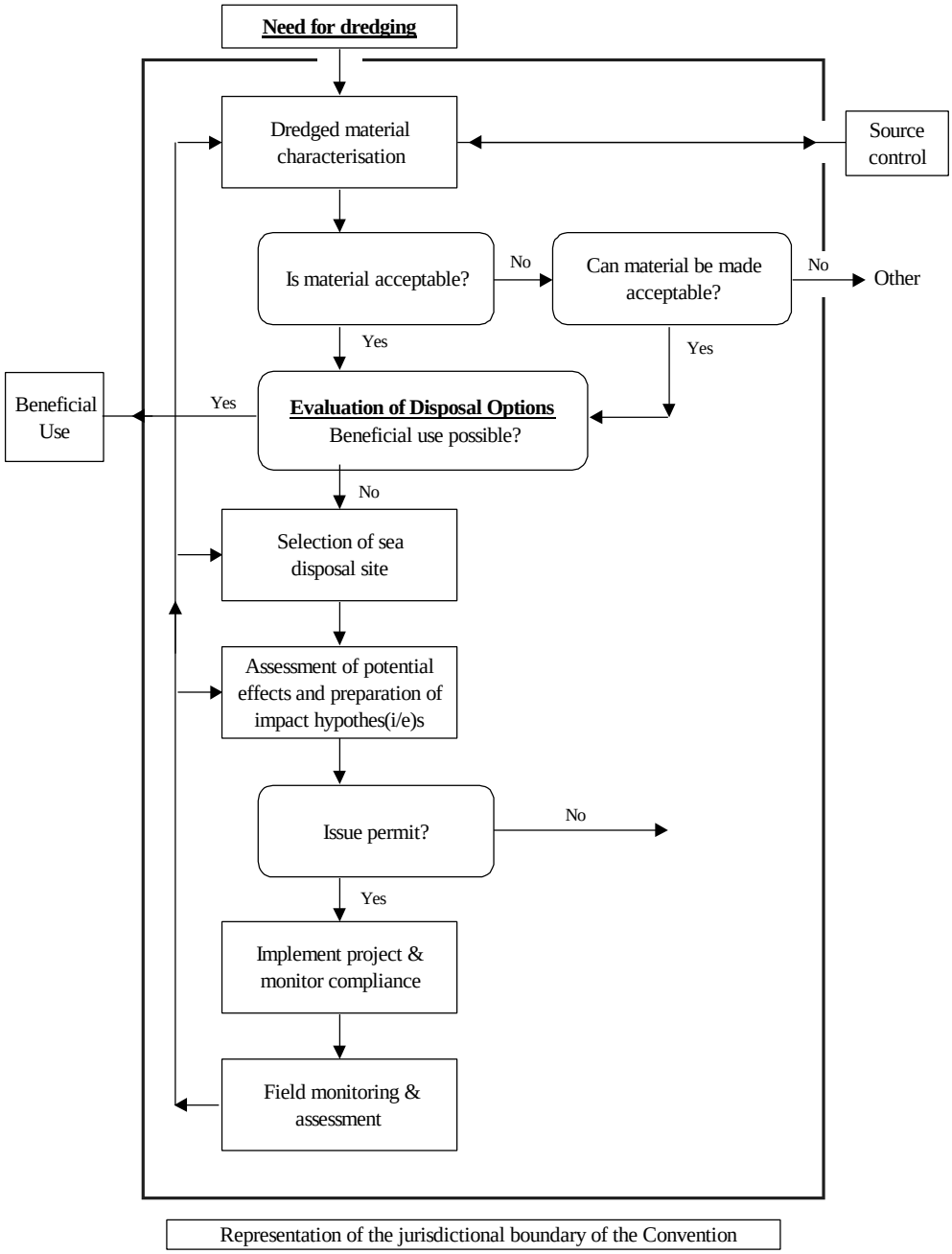
12.7 Concise statements of monitoring activities should be prepared. Reports should detail the measurements made, results obtained and how these data relate to the monitoring objectives. The frequency of reporting will depend upon the scale of disposal activity and the intensity of monitoring.

13. REPORTING

13.1 Reporting of permits issued and amounts of dredged material, dumped together with the associated contaminants, is required according to the 1992 OSPAR Convention - see paragraph 3.5 above. The characterisation process is designed to provide information for permitting purposes. However, it will also provide some information on the contribution ofdredged material to total inputs and, at the present time, it is considered the only approach available for this purpose. It is assumed that materials exempted from analysis represent insignificant inputs of contaminants and therefore it is not necessary to calculate or report contaminant loads. See paragraph 3.5 for the basis of this reporting requirement.

13.2 Contracting Parties should also inform the Secretariat of their monitoring activities and submit reports when they are available.

FLOW DIAGRAM



Background information and supplementary literature to the OSPAR Guidelines for the Management of Dredged Material

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Technical Annex I

Analytical Requirements for Dredged Material Assessment

1. This Technical Annex covers the analytical requirements necessary to implement paragraphs 5.4 - 5.9 of the OSPAR Guidelines for the Management of Dredged Material.

2. A tiered approach to testing is recommended. At each tier it will be necessary to determine whether sufficient information exists to allow a management decision to be taken or whether further testing is required.

3. As a preliminary to the tiered testing scheme, information required under section 5.3 of the Guidelines will be available. In the absence of appreciable pollution sources and if the visual determination of sediment characteristics lead to the conclusion that the dredged material meets one of the exemption criteria under paragraph 5.2 of the Guidelines, then the material will not require further testing. However, if all or part of the dredged material is being considered for beneficial uses, then it will usually be necessary, in order to evaluate these uses, to determine at least some of the physical properties of the material indicated in Tier I.

4. The sequence of tiers is as follows:

- assessment of physical properties
- assessment of chemical properties
- assessment of biological properties and effects

A pool of supplementary information, determined by local circumstances may be used to augment each tier (cf. section 5.5 of the Guidelines).

5. At each stage of the assessment procedure account must be taken of the method of analysis. Analysis should be carried out on the whole sediment (< 2mm) or in a fine-grained fraction. If analysis is carried out in a fine-grained fraction, the results should be appropriately converted to whole sediment (< 2 mm) concentrations for establishing total loads of the dredged material. Additional information (e.g. as regards storage and pre-treatment of samples, analytical procedures, analytical quality assurance) can be obtained in the JAMP Guidelines for Monitoring Contaminants in Sediments.

6. The physical composition of samples, and therefore the chemical and biological properties, can be strongly influenced by the choice of sampling sites, the method of sampling and sampling handling. These possible influences should be taken into account when evaluating data.

Tier I: PHYSICAL PROPERTIES.

Physical analyses are important because they help to indicate how the sediment may behave during dredging and disposal operations and indicate the need for subsequent chemical and/or biological testing. In addition to the visual determination of sediment characteristics required in section 5.3 of the Guidelines, it is strongly recommended that the following determinations be carried out:

Determinant	Indicating
• grain size (% sand, silt, clay) • percent solids (dry matter)	• Cohesiveness, settling velocity/resuspension potential, contaminant accumulation potential
• density/specific gravity	• Consolidation of placed material, volume *in situ* vs. after deposit
• organic matter (as total organic carbon)	• Potential accumulation of organic associated contaminants

When dredged material is being considered for beneficial uses, it will also usually be necessary to have available details of the engineering properties of the material eg. permeability, settling characteristics, plasticity and mineralogy.

Tier II: CHEMICAL PROPERTIES

The following trace metals should be determined in all cases:

Cadmium (Cd)	Copper (Cu)	Mercury (Hg)	Zinc (Zn)
Chromium (Cr)	Lead (Pb)	Nickel (Ni)	

The following organic/organo-metallic compounds should be determined:

- Polychlorinated biphenyl (PCB) congeners- IUPAC nos 28, 52, 101, 118, 138, 153 and 180.
- Polycyclic aromatic hydrocarbons (PAHs)
- Tri-Butyl Tin compounds and their degradation products

However, the determination of PCBs, PAHs and Tri-Butyl Tin compounds and its degradation products will not be necessary when:

a) sufficient information from previous investigations indicating the absence of contamination is available (cf. §§ 7.5- 7.7 in the OSPAR Guidelines for the Management of dredged Material); or

b)
- there are no known significant sources (point or diffuse) of contamination or historic inputs; and
- the sediments are predominantly coarse; and
- the content of total organic carbon is low.

When PCB analyses are undertaken, information on each of the congeners on the ICES primary list should be reported to the Commission.

Based upon local information of sources of contamination (point sources or diffuse sources) or historic inputs, other determinants may require analysis, for instance:

arsenic	other chlorobiphenyls[2]	organophosphorus pesticides	petroleum hydrocarbons
	organochlorine pesticides	other organotin compounds	Polychlorinated dibenzodioxins (PCDDs)/polychlorinated dibenzofurans (PCDFs)
	other anti-fouling agents		

In deciding which individual organic contaminants to determine, reference should be made to existing priority substance lists, such as those prepared by OSPAR and the EU [3].

Normalisation

It is recommended that normalised values of contaminants should be used to enable a more reliable comparison of contaminant concentrations in dredged material with those in sediments at disposal or reference sites, as well as with action levels. The normalisation procedure (see Technical Annex II) used within a regulatory authority should be consistent to ensure effective comparisons.

Analytical Techniques

Reference should be made to the Technical Annexes of the JAMP monitoring guidelines (cf. reference OSPAR, 1997) for recommended analytical techniques.

Tier III: BIOLOGICAL PROPERTIES AND EFFECTS

In a significant number of cases the physical and chemical properties described above do not provide a direct measure of the biological impact. Moreover, they do not adequately identify all physical disturbances and all sediment-associated constituents present in the dredged material. If the potential impacts of the dredged material to be dumped cannot be adequately assessed on the basis of the chemical and physical characterisation, biological measurements should be carried out.

The selection of an appropriate suite of biological test methods will depend on the particular questions addressed, the level of contamination at the dredging site and the degree to which the available methods have been standardised and validated.

To enable the assessment of the test results, an assessment strategy should be developed with regard to granting a permit authorising disposal at sea. The extrapolation of test results on individual species to a higher level of biological organisation (population, community) is still very difficult and requires good knowledge of assemblages that typically occur at the sites of interest.

2 cf. Joint Assessment and Monitoring Programme (JAMP) Guidelines for Monitoring Contaminants in Sediments.

3 Communication of 22 June 1982 from the Commission to the Council on hazardous substances within the meaning of List I of Council Directive 76/464/EEC. Official Journal of the European Communities C 176, 14.7.1982, p.3

1. Toxicity bioassays:

   The primary purpose of toxicity bioassays is to provide direct measures of the effects of all sediment constituents acting together, taking into account their bioavailability. For ranking and classifying the acute toxicity of harbour sediment prior to maintenance dredging, short-term bioassays may often suffice as screening tools.

   - To evaluate the effects of the dredged material, acute bioassays can be performed with pore water, an elutriate or the whole sediment In general, a set of 2-4 bioassays is recommended with organisms from different taxonomic groups (e.g. crustaceans, molluscs, polychaetes, bacteria, echinoderms);
   - In most bioassays, survival of the test species is used as an endpoint. Chronic bioassays with sub-lethal endpoint (growth, reproduction etc) covering a significant portion of the test species life cycle may provide a more accurate prediction of potential impact of dredging operations. However, standard test procedures are still under development;

   The outcome of sediment bioassays can be unduly influenced by factors other than sediment-associated chemicals. Confounding factors like ammonia, hydrogen sulphide, grain size, oxygen concentration and pH should therefore be determined during the bioassay.

   Guidance on the selection of appropriate test organisms, use and interpretation of sediment bioassays is given by eg. EPA/CE (1991/1994) and IADC/CEDA (1997) while guidance on sampling of sediments for toxicological testing is given by e.g. ASTM (1994).

2. Biomarkers:

   Biomarkers may provide early warning of more subtle (biochemical) effects at low and sustained levels of contamination. Most biomarkers are still under development but some are already applicable for routine application on dredged material (e.g. one which measures the presence of dioxin-like compounds - Murk *et al*., 1997) or organisms collected in the field (e.g. DNA strand/breaks in flat fish).

3. Microcosm experiments:

   There are short-term microcosm tests available to measure the toxicant tolerance of the community e.g. Pollution Induced Community Tolerance (PICT) (Gustavson and Wangberg, 1995)

4. Mesocosm experiment:

   In order to investigate long-term effects, experiments with dredged material in mesocosms can be performed, for instance to study the effects of PAHs in flatfish pathology. Because of the costs and time involved these experiments are not applicable in the process of authorising permits but are useful in cases where the extrapolation of laboratory testing to field condition is complicated r environmental conditions are very variable and hinder the identification of toxic effects as such. The results of these experiments would be then available for future permitting decisions.

5. Field observation of benthic communities:

   Monitoring in the surrounding of the disposal site of benthic communities e.g. *in situ* (fish, benthic invertebrates) can give important clues to the condition of marine sediments and are relevant as a feed-back or refinement process for authorising permits. Field observations give insight into the combined impact

of physical disturbance and chemical contamination. Guidelines on the monitoring of benthic communities are provided by e.g. OSPAR, ICES, HELCOM.

6. Other biological properties:

   Where appropriate, other biological measurements can be applied in order to determine e.g. the potential for bioaccumulation and for tainting.

SUPPLEMENTARY INFORMATION

The need for further information will be determined by local circumstance and may form an essential part of the management decision. Appropriate data might include: redox potential, sediment oxygen demand, total nitrogen, total phosphorus, iron, manganese, mineralogical information or parameters for normalising contaminant data (e.g. aluminium, lithium, scandium– cf. Technical Annex II). Consideration should also be given to chemical or biochemical changes that contaminants may undergo when disposed of at sea.

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JAMP Eutrophication Monitoring Guidelines: Benthos- Technical Annex 1 (Hard-bottom macrophytobenthos and hard-bottom macrozoobenthos) - Technical Annex 2 (Soft-bottom macrozoobenthos)

JAMP Guidelines for Monitoring Contaminants in Sediments

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Technical Annex II[4]

Normalisation Techniques for Studies on the Spatial Distribution of Contaminants*

1. Introduction

Normalisation in this discussion is defined as a procedure to compensate for the influence of natural processes on the measured variability of the concentration of contaminants in sediments. Most contaminants (metals, pesticides, hydrocarbons) show high affinity to particulate matter and are, consequently, enriched in bottom sediments of estuaries and coastal areas. In practice, natural and anthropogenic substances entering the marine system are subjected to a variety of biogeochemical processes. As a result, they become associated with fine-grained suspended solids and colloidal organic and inorganic particles. The ultimate fate of these substances is determined, to a large extent, by particulate dynamics. They therefore tend to accumulate in areas of low hydrodynamic energy, where fine material is preferentially deposited. In areas of higher energy, these substances are "diluted" by coarser sediments of natural origin and low contaminant content.

It is obvious that the grain size is one of the most important factors controlling the distribution of natural and anthropogenic components in the sediments. It is, therefore, essential to normalise for the effects of grain size in order to provide a basis for meaningful comparisons of the occurrence of substances in sediments of various granulometry and texture within individual areas or among areas. Excess levels, above normalised background values, could then be used to establish sediment quality.

For any study of sediments, a basic amount of information on their physical and chemical characteristics is required before an assessment can be made on the presence or absence of anomalous contaminant concentrations. The concentration at which contamination can be detected depends on the sampling strategy and the number of physical and chemical variables that are determined in individual samples.

The various granulometric and geochemical approaches used for the normalisation of trace elements data as well as the identification of contaminated sediments in estuarine and coastal sediments has been extensively reviewed by Loring (1988). Two normalisation approaches widely used in oceanography and in atmospheric sciences have been selected here. The first is purely physical and consists of characterising the sediment by measuring its content of fine material. The second approach is chemical in nature and is based on the fact that the small size fraction is usually rich in clay minerals, iron and manganese oxi-hydroxides and organic matter. Furthermore, these components often exhibit a high affinity for organic and inorganic contaminants and are responsible for their enrichment in the fine fraction. Chemical parameters (e.g., Al, Sc, Li) representative of these components may thus be used to characterise the small size fraction under natural conditions.

It is strongly suggested that several parameters be used in the evaluation of the quality of sediments. The types of information that can be gained by the utilisation

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[4] This Technical Annex is currently under review in the framework of OSPAR's Working Group on Concentrations, Trends and Effects of Substances in the Marine Environment (SIME).

* Extract from the 1989 ACMP Report (Section 14). ICES Coop. Res. Rep. 167, pp 68-76

of these various parameters are often complementary and extremely useful considering the complexity and diversity of situations encountered in the sedimentary environment. Furthermore, measurements of the normalising parameters selected here are rather simple and inexpensive.

This report presents general guidelines for sample preparation, analytical procedures, and interpretation of physical and chemical parameters used for the normalisation of geochemical data. Its purpose is to demonstrate how to collect sufficient data to normalise for the grain-size effect and to allow detection, at various levels, of anomalous concentrations of contaminants within estuarine and coastal sediments.

2. Sampling Strategy

Ideally, a sampling strategy should be based on a knowledge of the source of contaminants, the transport pathways of suspended matter and the rates of accumulation of sediments in the region of interest. However, existing data are often too limited to define the ideal sampling scheme. Since contaminants concentrate mainly in the fine fraction, sampling priority should be given to areas containing fine material that usually correspond to zones of deposition.

The high variability in the physical, chemical and biological properties of sediments implies that an evaluation of sediment quality in a given area must be based on a sufficient number of samples. This number can be evaluated by an appropriate statistical analysis of the variance within and between samples. To test the representativity of a single sediment specimen at a given locality, several samples at one or two stations should be taken.

The methodology of sampling and analysis should follow the recommendations outlined in the "Guidelines for the Use of Sediments as a Monitoring Tool for Contaminants in the Marine Environment" (ICES 1987). In most cases, the uppermost layer of sediments collected with a tightly closing grab sampler (Level I in the Guidelines) is sufficient to provide the information concerning the contamination of the sediments of a given area compared to sediments of uncontaminated locations or other reference material.

Another significant advantage of using sediments as monitoring devices is that they have recorded the historical evolution of the composition of the suspended matter deposited in the area of interest. Under favourable conditions, the degree of contamination may be estimated by comparison of surface sediments with deeper samples, taken below the biological mixing zone. The concentrations of trace elements in the deeper sediment may represent the natural background level in the area in question and can be defined as baseline values. This approach requires sampling with a box-corer or a gravity corer (Levels II and III in the Guidelines).

3. Analytical Procedures

Typical analytical procedures to be followed are outlined in Table 1. The number of steps that are selected will depend on the nature and extent of the investigation.

3.1 Grain size fractionation

It is recommended that at least the amount of material <63 µm, corresponding to the sand/silt classification limit, be determined. The sieving of the sample at 63 µm is, however, often not sufficient, especially when sediments are predominantly fine grained. In such cases, it is better to normalise with lower size thresholds since the

contaminants are mainly concentrated in the fraction <20µm, and even more specifically in the clay fraction (<2µm). It is thus proposed that a determination be made, on a sub-sample, of the weight fraction <20 µm and that <2 µm with the aid of a sedimentation pipette or by elutriation. Several laboratories are already reporting their results relative to the content of fine fractions of various sizes and these results may be useful for comparison among areas.

3.2 Analysis of contaminants

It is essential to analyse the total content of contaminants in sediments if quality assessment is the goal of the study, and it is thus recommended that the unfractionated sample (<2 mm) be analysed in its entirety. The total content of elements can be determined either by non-destructive methods, such as X-ray fluorescence or neutron activation, or by a complete digestion of the sediments (involving the use of hydrofluoric acid (HF)) followed by methods such as atomic absorption spectrophotometry or emission spectroscopy. In the same way, organic contaminants should be extracted with the appropriate organic solvent from the total sediment.

An individual size fraction of the total sediment may be used for subsequent analysis, if required, to determine the absolute concentrations of contaminants in that fraction, providing that its contribution to the total is kept in perspective when interpreting the data. Such size fraction information might be useful in tracing the regional dispersal of metals associated with specific grain-size fractions, when the provenance of the material remains the same. However, sample fractionation is a tedious procedure that introduces considerable risk of contamination and potential losses of contaminants due to leaching. The applicability of this approach is thus limited.

4. Normalisation Procedures

4.1 Granulometric normalisation

Since contaminants tend to concentrate in the fine fraction of sediments, correlations between total concentrations of contaminants and the weight percent of the fine fraction, determined separately on a sub-sample of the sediment by sieving or gravity settling, constitute a simple but powerful method of normalisation. Linear relationships between the concentration and the weight percentage of the fine fraction are often found and it is then possible to extrapolate the relationships to 100% of the fraction studied, or to characterise the size dependence by the slope of the regression line.

4.2 Geochemical normalisation

Granulometric normalisation alone is inadequate to explain all the natural trace variability in the sediments. In order to interpret better the compositional variability of sediments, it is also necessary to attempt to distinguish the sedimentary components with which the contaminants are associated throughout the grain-size spectrum. Since effective separation and analysis of individual components of sediments is extremely difficult, such associations must rest on indirect evidence of these relationships.

Since contaminants are mainly associated with the clay minerals, iron and manganese oxi-hydroxides and organic matter abundant in the fine fraction of the sediments, more information can be obtained by measuring the concentrations of elements representative of these components in the samples.

An inert element such as aluminium, a major constituent of clay minerals, may be selected as an indicator of that fraction. Normalised concentrations of trace elements with respect to aluminium are commonly used to characterise various sedimentary particulate materials (see below). It may be considered as a conservative major element, that is not affected significantly by, for instance, early diagenetic processes and strong redox effects observed in sediments.

In the case of sediments derived from the glacial erosion of igneous rocks, it has been found that contaminant/Al ratios are not suitable for normalising for granular variability (Loring, 1988). Lithium, however, appears to be an ideal element to normalise for the grain size effect in this case and has the additional advantage of being equally applicable to non-glacial sediments.

In addition to the clay minerals, Mn and Fe compounds are often present in the fine fraction, where they exhibit adsorption properties strongly favouring the incorporation of various contaminants. Mn and Fe are easily analysed by flame atomic absorption spectrometry and their measurement may provide insight into the behaviour of contaminants.

Organic matter also plays an important role as scavenger of contaminants and controls, to a major degree, the redox characteristics of the sedimentary environment.

Finally, the carbonate content of sediments is easy to determine and provides additional information on the origin and the geochemical characteristics of the sediments. Carbonates usually contain insignificant amounts of trace metals and act mainly as a diluent. Under certain circumstances, however, carbonates can fix contaminants such as cadmium and copper. A summary of the normalisation factors is given in Table 2.

4.3 Interpretation of the data

The simplest approach in the geochemical normalisation of substances in sediments is to express the ratio of the concentration of a given substance to that of the normalising factor.

Normalisation of the concentration of trace elements with respect to aluminium (or scandium) has been used widely and reference values on a global scale have been established for trace elements in various compartments: crustal rocks, soils, atmospheric particles, river-borne material, marine clays and marine suspended matter (cf., e.g., Martin and Whitfield, 1983; Buat-Menard and Chesselet, 1979).

This normalisation also allows the definition of an enrichment factor for a given element with respect to a given compartment. The most commonly used reference level of composition is the mean global normalised abundance of the element in crustal rock (Clarke value).

The enrichment factor EF is given by:

$$EF_{crust} = (X/Al)_{sed} / (X/Al)_{crust}$$

where X/Al refers to the ratio of the concentration of element X to that of Al in the given compartment.

However, estimates of the degree of contamination and time trends of contamination at each sampling location can be improved upon by making a comparison with metal levels in sediments equivalent in origin and texture.

These values can be compared to the normalised values obtained for the sediments of a given area. Large departures from these mean values indicate either contamination of the sediment or local mineralisation anomalies.

When other variables (Fe, Mn, organic matter and carbonates) are used to characterise the sediment, regression analysis of the contaminant concentrations with these parameters often yields useful information on the source of contamination and on the mineralogical phase associated with the contaminant.

A linear relationship between the concentration of trace constituents and that of the normalisation factor has often been observed (Windom et al., 1989). In this case and if the natural geochemical population of a given element in relation to the normalising factor can be defined, samples with anomalous normalised concentrations are easily detected and may indicate anthropogenic inputs.

According to this method, the slope of the linear regression equation can be used to distinguish the degree of contamination of the sediments in a given area. This method can also be used to show the change of contaminant load in an area if the method is used on samples taken over intervals of some years (Cato, 1986).

A multi-element/component study in which the major and trace metals, along with grain size and organic carbon contents, have been measured allows the interrelationships between the variables to be established in the form of a correlation matrix. From such a matrix, the most significant ratio between trace metal and relevant parameter(s) can be determined and used for identification of metal carriers, normalisation and detection of anomalous trace metal values. Factor analyses can sort all the variables into groups (factors) that are associations of highly correlated variables, so that specific and/or non-specific textural, mineralogical, and chemical factors controlling the trace metal variability may be inferred from the data set.

Natural background levels can also be evaluated on a local scale by examining the vertical distribution of the components of interest in the sedimentary column. This approach requires, however, that several favourable conditions are met: steady composition of the natural uncontaminated sediments; knowledge of the physical and biological mixing processes within the sediments; absence of diagenetic processes affecting the vertical distribution of the component of interest. In such cases, grain-size and geochemical normalisation permits compensation for the local and temporal variability of the sedimentation processes.

5. Conclusions

The use of the granulometric measurements and of component/reference element ratios are useful approaches towards complete normalisation of granular and mineralogical variations, and identification of anomalous concentrations of contaminants in sediments. Their use requires that a large amount of good analytical data be collected and specific geochemical conditions be met before all the natural variability is accounted for, and the anomalous contaminant levels can be detected. Anomalous metal levels, however, may not always be attributed to contamination, but rather could easily be a reflection of differences in sediment provenance.

Geochemical studies that involve the determination of the major and trace metals, organic contaminants, grain size parameters, organic matter, carbonate, and mineralogical composition in the sediments are more suitable for determining the factors that control the contaminant distribution than the measurement of absolute concentrations in specific size fractions or the use of potential contaminant/reference metal ratios alone. They are thus more suitable for distinguishing between uncontaminated and contaminated sediments. This is because such studies can identify the factors that control the variability of the concentration of contaminants in the sediments.

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Table 1

A typical approach for determinations of physical and chemical parameters in marine sediments

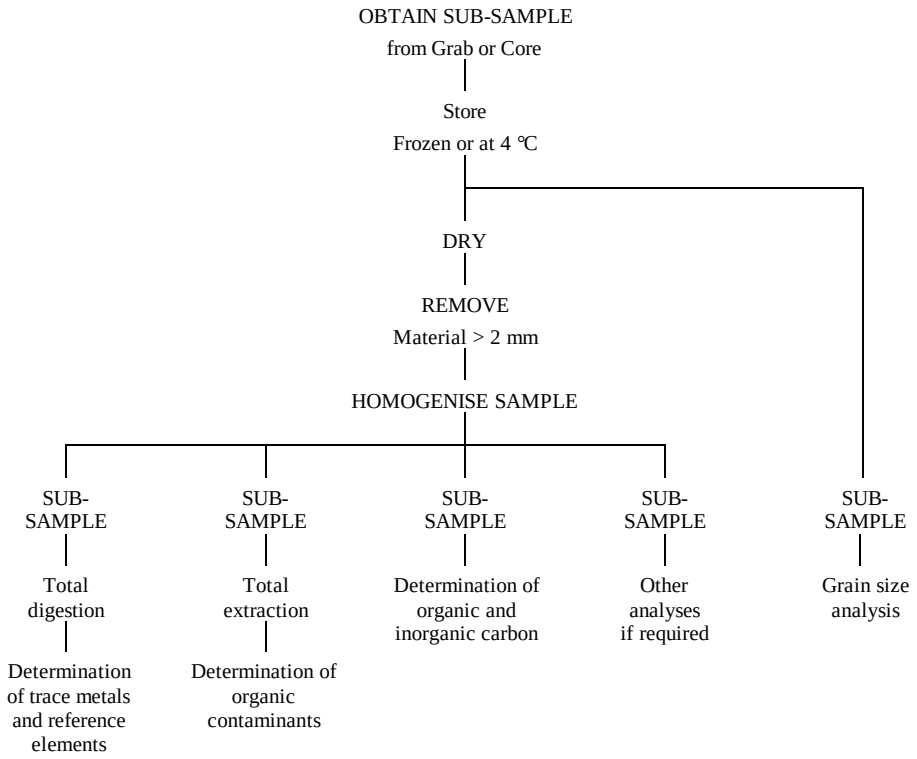


Table 2

Summary of normalisation factors

NORMALISATION FACTOR	SIZE (mm)	INDICATOR	ROLE
Textural			Determines physical sorting and depositional pattern of metals
Sand	2000 – 63	Coarse-grained metal-poor minerals/ compounds	Usually diluent of trace metal concentrations
Mud	< 63	Silt and clay size metal-bearing minerals / compounds	Usually overall concentrator of trace metals
Clay	< 2	Metal-rich clay minerals	Usually fine-grained accumulator of trace metals
Chemical			
Si		Amount and distribution of metal-poor quartz	Coarse-grained diluter of contaminants
Al		Al silicates, but used to account for granular variations of metal-rich fine silt and clay size Al-silicates	Chemical tracer of Al-silicates, particularly the clay minerals
Li, Sc		Structurally combined in clay minerals and micas	Tracer of clay minerals, particularly in sediments containing Al-silicates in all size fractions
Organic carbon		Fine-grained organic matter	Tracer of organic contaminants. Sometimes accumulator of trace metals like Hg and Cd
Fe, Mn		Metal-rich silt and clay size Fe-bearing clay minerals, Fe-rich heavy minerals and hydrous Fe and Mn oxides	Chemical tracer for Fe-rich clay fraction. High absorption capacity of organic and inorganic contaminants
Carbonates		Biogenic marine sediments	Diluter of contaminants. Sometimes accumulate trace metals like Cd and Cu

Technical Annex III

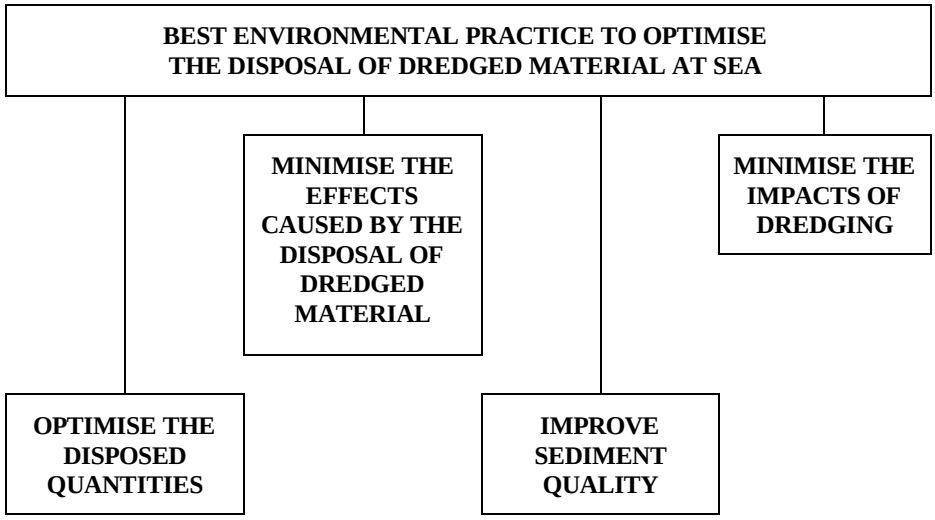
Best Environmental Practice (BEP)

Introduction

This Technical Annex was prepared bearing in mind that, although the guidelines strictly only apply to the disposal of dredged material, Contracting Parties are encouraged also to exercise control over dredging operations.

This Technical Annex has as its aim to provide guidance to national regulatory authorities, operators of dredging vessels and port authorities on how to minimise the effects on the environment of dredging and disposal operations. Careful assessment and planning of dredging operations are necessary to minimise the impacts on marine species and habitats.

The items given as BEP under the different headings of this Technical Annex are given as examples. Their applicability will generally vary according to the particular circumstances of each operation and it is clear that different approaches may then be appropriate. More detailed information on dredging techniques and processes can be found in Guide 4 of the IADC/CEDA series on Environmental Aspects of Dredging.



Point A - Minimisation of the effects caused by the disposal of dredged material - is comprehensively described in the main body of these guidelines.

Point B ‘Optimisation of the disposed quantities’, Point C ‘Improvement of sediment quality’ and Point D ’Minimise the Impacts of Dredging’ do not fall within the strict remit of the Oslo Commission, but are very relevant to the prevention of pollution of the marine environment resulting from the disposal of dredged materials. Descriptions of BEP in relation to these activities are given at Appendices I and II.

OPTIMISE THE DISPOSED QUANTITIES

KEEP VOLUME OF DREDGED MATERIAL MINIMAL

IM

MINIMISE NEED FOR DREDGING

In fluid mud areas: introduce the concept of Navigable depth based on:

- *physico-chemical evaluation of the sediment (including rheometry and densimetry)*
- *full scale trials*

BEP: ***Dredging only the amount of material required for maintaining a particular density level to allow navigation. This may require*** e.g. *continuous underway measurement of sediment density by using a nuclear transmission gauge or measurement of shear forces.*

In areas with sandy waves etc.

BEP: - *selective dredging of sand waves and other mobile sand structures*

Hydraulic Engineering

BEP: - *use of hydraulic structures to reducesedimentation*

Accurate monitoring of dredged depths at an appropriate frequency

BEP: - *accurate positioning systems e.g.:*
  - *microwave systems*
  - *radiowave technology*
  - *DGPS*
- *apply rapid survey equipment*
  - *continuous measurement systems*
  - *echosounders*
  - *swath/multibeam systems*

OPTIMISE DREDGING OPERATIONS MANAGEMENT

Accurate survey systems

(see column 1: Accurate monitoring)

Availability of survey data on board

BEP: - *on-line visualisation of updated bathymetric charts, including topographic data, coastlines, disposal areas, dredge position, dredge head position*
- *tidal information*

Process evaluation

BEP: - *visualisation/evaluation of dredged tracks/profiles/zones*
- *dredging intensity chart*
- *in case of muddy material, sand and gravel: establish optimum overflow time by analysis of load diagrams*

Effective d

BEP: -

-

-

-

-

Output im

BEP: -

-

-

-

Selective d

BEP: -

See IAD
Introductio

IMPROVE SEDIMENT QUALITY

M

IN SITU BEFORE DREDGING AND AFTER DISPOSAL

Improve physical aspects (cohesion, consistency, density) of dredged material

BEP: - *increase sediment density by physical means e.g. vibration*

IN THE HOPPER

Mechanical separation

BEP:
- *hydrocyclones for separation of granulometric fractions*
- *flotation*
- *dewatering (under development)*

(consider potential problems with process water and associated contaminants e.g. re-circulation will reduce problems

Minimis

BEP:

Minimis

BEP: