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HUMAN ACTIVITIES, PRESSURES AND IMPACTS STEERING GROUP

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## Interim Report of the Working Group on Marine Sediments in Relation to Pollution (WGMS)

5–9 March 2018

San Pedro del Pinata, Spain



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## Contents

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<b>Executive summary .....</b>	<b>2</b>
<b>1 Administrative details .....</b>	<b>3</b>
<b>2 Terms of Reference.....</b>	<b>3</b>
<b>3 Summary of Work plan .....</b>	<b>4</b>
<b>4 List of Outcomes and Achievements of the WG in this delivery period .....</b>	<b>4</b>
<b>5 Progress report on ToRs and workplan .....</b>	<b>4</b>
5.1 ToR A: Requests.....	4
5.2 ToR B: Dredging Activities.....	5
5.3 ToR C: Sediment Quality Guidelines .....	8
5.4 ToR D: Plastic litter .....	9
5.5 ToR E: Emerging issues.....	12
5.6 ToR F: Impact of renewable energy devices .....	15
5.7 ToR G: Passive sampling .....	16
<b>6 Revisions to the work plan and justification .....</b>	<b>18</b>
<b>7 Next meetings.....</b>	<b>18</b>
<b>Annex 1: List of participants.....</b>	<b>19</b>
<b>Annex 2: Review and suggestions about the management of dredging activities.....</b>	<b>21</b>

## Executive summary

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The Working Group on Marine Sediments in Relation to Pollution (WGMS) met on 5–9 March 2018, in San Pedro del Pinatar (Murcia, Spain). The meeting was co-chaired by C Robinson (UK) and MJ Belzunce Segarra (Spain) and attended by six members from four countries, plus one member of the hosting institute (IEO). Additionally, contributions were received from five members from five countries and additional contributions from Italian and Spanish experts.

WGMS has five Terms of Reference (ToR) due for completion in 2020, and one ToR to complete in 2019. These require the Group to (1) complete the guidelines and review on passive sampling techniques and work to progress on the development of database related with assessment criteria for passive sampling; (2) review the regulated substances and thresholds used in management of dredging activities and monitoring the disposal sites; (3) review the existing sediment quality criteria; (4) assess the relevance and the potential risk impact of (micro-) plastics in sediments; (5) review the occurrence of substances of emerging concern; (6) investigate/review the potential for release of contaminants from marine renewable energy activities.

In 2018, good progress was made on all ToRs. Valuable inputs were made by staff of the host institute to ToR E (contaminants of emerging concern) and by videoconference contributions to ToR B (Dredging Activities) and ToR G (Passive Sampling). Special focus was put on the potential impacts of the marine micro-plastics (ToR D), with two presentations and discussion. Work to progress the ToRs further was agreed.

Three documents for publication under ToR G were further worked on and are nearing completion.

## 1 Administrative details

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<p><b>Working Group name</b> Working Group on Marine Sediments in Relation to Pollution (WGMS)</p> <p><b>Year of Appointment within current cycle</b> 2018</p> <p><b>Reporting year within current cycle (1, 2 or 3)</b> 1</p> <p><b>Chair(s)</b> Craig Robinson, Scotland, UK Maria Jesus Belzunce Segarra, Spain</p> <p><b>Meeting dates</b> 5–9 March 2018</p> <p><b>Meeting venue</b> San Pedro del Pinatar (Murcia), Spain</p>
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## 2 Terms of Reference

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<b>A</b>	<b>Respond to requests for advice from Regional Seas Conventions</b> (e.g. OSPAR, EU) as required.
<b>B</b>	<b>Dredging Activities:</b> B1 - Review the regulated substances and thresholds used in management of dredging activities. B2 – Review and recommend monitoring approaches to disposal sites.
<b>C</b>	<b>Sediment Quality Guidelines</b> Review recent publications that may contain data to refine existing sediment assessment criteria.
<b>D</b>	<b>Plastic litter:</b> To assess the relevance and the potential risk impact of (micro-) plastics in sediments and follow up of outcomes of other expert groups.
<b>E</b>	<b>Emerging issues:</b> E1- To review and inform on the occurrence of substances of emerging concern in sediments, including platinum group and rare earth elements, as well as organic contaminants. E2- To consider other forms of pollution, e.g. microbiological.
<b>F</b>	<b>Impact of renewable energy devices</b> To explore the potential risk impact in terms of inputs (corrosion, anti-corrosion agents...) and release of contaminants due to sediment scouring.

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<b>G</b>	<b>Passive sampling</b>
	G1- To publish guidelines on passive sampling of sediments
	G2- To publish a review on passive sampling of sediments
	G3- Review and update on developments
	G 4- Continue to develop a database to provide information of use in developing assessment criteria for passive sampling techniques

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### 3 Summary of Work plan

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Year 1	Completion of the different draft documents on Passive Sampling (PS) and submission as two ICES TIMES papers (Guidelines on PS in sediments) and one Cooperative Research Report on the techniques for passive sampling of marine sediments. Progress work towards completion of the remaining ToRs
Year 2	Progress work towards completion of the remaining ToRs
Year 3	Final Report

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### 4 List of Outcomes and Achievements of the WG in this delivery period

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- Worked progressed on all ToRs
- Work nearing completion on three documents for which publication Resolutions were approved by ICES in 2017

### 5 Progress report on ToRs and workplan

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#### 5.1 ToR A: Requests

ToR A - Respond to requests for advice from Regional Seas Conventions (e.g. OSPAR, EU) as required.	3 years	Requested advice
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There were no specific RSC requests for WGMS advice this year.

## 5.2 ToR B: Dredging Activities

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ToR B1 - Review the regulated substances and thresholds used in management of dredging activities.	A major source of contaminants in marine sediments. The substances considered, their thresholds, and the management approaches are different in each country.	3 years	Review document and recommendation, if required.
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A review document was begun, looking at what substances are regulated by licensing authorities in different European countries, what Action Levels are used, and the processes by which the licensing authorities permit dredging operations and the disposal of dredged materials (Annex 2). This has highlighted significant differences in each of these approaches between different countries. This document will be further worked upon in the next meetings to produce a review document that may form a future Cooperative Research Report.

### **Presentation: Conceptual and software assisted weight of evidence approach for sediment quality assessment**

**Francesco Regoli (UNIVPM, IT)**

Introduction of sediment quality assessment for dredged material using a new risk based, weight of evidence approach, integrating chemical and ecotoxicological results into a software algorithm. Originally, if only one parameter falls above set threshold, for chemical or ecotoxicological tests, the dredge material was defined as failing the overall required sediment quality assessment. Now chemical and ecotoxicological thresholds are weighted to risk, based on relative hazard and magnitude, and an overall weight of evidence is used to provide a sediment quality index (HQ) based on 5 categories ( A absent - negligible; B - slight; C - moderate; D - major and E - severe risk). The software developed is flexible, allowing for input of different references. Tests have been completed comparing the old approach with this new approach, and show that for extremes the same result is achieved, but the new approach enables better assessment for interim sediment quality categories (B, C and D). Highlighted that industry liked this approach, as although sampling and analyses costs are relatively high, this approach allows better evidence base, potentially allowing different management options.

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ToR B2 - Review and recommend monitoring approaches to disposal sites	Sediments are a sink for many pollutants, but also can be a source.	3 years	Review document and recommendation, if required.
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### **Updates regarding monitoring approaches at disposal sites were provided by members**

Birgit Schubert attended the Dredging in Europe (DGE) meeting “Special session on monitoring of aquatic deposit sites for dredged material – Consideration of the requirements of international regulations and practical implementation” on 20 February 2018.

In summary, in terms of legislation, the Marine Strategic Framework Directive (MSFD) mentions dredge disposal activity in Annex 3, Table 2: Pressure and Impacts under phys-

ical loss (smothering) and physical damage (changes in siltation). It does not include specific requirements related to monitoring of deposit sites. No other EU directives address monitoring of disposal sites specifically. Nevertheless, as the EU regulations aim at achieving a good environmental status, they may influence the handling of dredged material. The non-deterioration principle or the request for improvement of water quality in the Water Framework Directive, for example, might have implications for dredge material disposal.

The Dredged Material Guidelines of OSPAR and HELCOM, however, stipulate monitoring at selected deposit sites and its surroundings. There is no obligation to monitor all deposit sites and monitoring results may be transferred to disposal activities with similar conditions.

DGE members agreed that the main objectives of monitoring are to check whether dredge material disposal complies with the license requirements, and whether the observed effects are within the predicted range. Furthermore, monitoring results may answer wider questions and improve the understanding of (natural) processes.

Some examples of monitoring programmes at disposal sites were presented. The projects varied greatly, from small projects depositing non-contaminated sediments to larger projects, depositing large volumes of contaminated dredged material. In addition, the characteristics of deposit sites varied greatly. There were disposal sites used in areas with high hydrodynamics, as well as an example of disposal of dredged material in gravel pits.

Usually, monitoring is restricted to selected disposal sites where problems are expected or when there is a change in the intensity of dredging activities. Furthermore, monitoring is mostly restricted to critical issues where effects are expected or have to be excluded. The monitoring issues are often derived from an environmental impact assessment.

For some projects, there was no obligation to monitor. However, for other projects, requirements on monitoring were fixed in the license.

The main elements of monitoring are baseline studies, compliance monitoring to check whether effects are within the expected ranges, monitoring of reference sites and monitoring at the disposal site and the surrounding area. Occasionally, results from sediment transport modelling supported the design of the monitoring programme. There were also differences in the number of disposal sites monitored, as well as the frequency and extent of monitoring between the monitoring programmes of different countries. All projects had a baseline study in common, either including new investigations or based on existing knowledge. Sometimes monitoring was performed during the period when dredge disposal at the disposal sites was on-going, sometimes after disposal activity.

It is quite common to monitor bathymetry. Furthermore, sediment composition often is monitored. If contaminated dredged material is deposited, contamination at the disposal site and its surroundings usually is monitored. When fine dredged material is deposited, turbidity may be monitored, and measurements may be carried out during a disposal campaign. In some projects benthic communities or generally faunistic communities were investigated. If disposal sites are within or close to Natura 2000 areas or other protected areas, investigations are more comprehensive. There was some concern on the applica-



tion of biotests in monitoring, as sometimes results for one sample analysed in two different laboratories strongly differed and made assessment difficult.

The most comprehensive monitoring programme presented had been performed for depositing of contaminated sediments at a site with lower contamination. Requirements for monitoring are included in the licence as well as some threshold values. Physical impacts only had to be monitored for non-contaminated dredged material in beneficial use schemes.

From the Italian presentation under ToR B(1) above, it was noted that if dredged material was classified as Grade B or above (i.e. all but the cleanest material), then post-disposal monitoring is required under Italian law. This would be site-specific depending upon the pressure(s).

In the next 2 years, WGMS plans to continue to gather further evidence of dredge disposal monitoring approaches, aiming to provide an overview report, potentially with a flow chart/decision tree and recommendations.

### **Presentation: How England monitors disposal sites**

#### **Jemma Lonsdale and Stefan Bolam**

Presented by Claire Mason. Originally presented at 24th DGE conference, Ministry of Environment and Food of Denmark, Copenhagen, on 20 February

There are 246 disposal sites in England, of which 173 are open. Trials alongside monitoring requirements are completed when new disposal sites are created. A monitoring programme, dating back to the 1980s, aims to ensure environmental conditions at newly designated sites are suitable for the commencement of disposal activities, predictions concerning environmental impacts continue to be met and disposal operations conform with licence conditions. Generally, 5 - 6 sites are targeted for monitoring within any one year. They are selected based on the relative magnitude of the issues pertaining to the site, such as a significant increase in the quantity of material disposed; the material to be disposed is a very different sediment type to that of the receiving environment; and/or there is the potential for the occurrence of elevated contaminant concentrations. A wide range of parameters are measured, dependant on the specific issues being assessed, taking into account the site variability with respect to their physical setting, their disposal regime and the nature of their issues. Results from survey work contribute directly to the licensing process by ensuring that any evidence of unacceptable changes or practices is rapidly communicated to the Marine Management Organisation (MMO). Dissemination of results occurs by an annual project report (downloadable from the [www.Defra.gov.uk](http://www.Defra.gov.uk) website); direct communication with the MMO; and through peer-review publications on site-specific or non-site-specific impacts.

### 5.3 ToR C: Sediment Quality Guidelines

ToR c - Review recent publications that may contain data to refine existing sediment assessment criteria	More data may be available to refine existing BACs/EACs; there are no existing criteria for some priority substances (e.g. PBDEs) for use in MSFD / OSPAR status assessments.	3 years	Annual updates and final report.
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Sediment quality guidelines are used to assess the state of the marine environment. For sediments, there are two types of assessment criteria used by OSPAR: Background Assessment Concentrations (BACs) and Environmental Assessment Criteria (EACs). However, BACs and EACs are only available for a limited suite of contaminants. There are no existing criteria for some priority substances, e.g. PBDEs, hexabromocyclododecanes (HBCDs or sometimes abbreviated HBCDDs); dioxins (PCDD/Fs) and dioxin-like PCBs; and PFOS and other polyfluorinated alkyl substances (PFAS)) for use in Marine Strategy Framework Directive (MSFD) and OSPAR status assessments.

This year the group compiled a table of sediment assessment criteria, from all countries, known to be currently available (OSPAR, 2009; UNEP/MAP 2016; Simpson and Batley, 2016; MAPAMA, 2012a,b; Long *et al.*, 1995, etc.). Additional information was received from Spain on the development of Background concentrations for PAHs (below). WGMS members are requested to add any further sediment assessment criteria in the next year ready for the next meeting.

Within the next two years, WGMS members have outlined the following plan:

- To determine which contaminants are relevant to sediments, with reference to the priority substance list (2013/39/EU Priority Substances Annex 1) as well as expert knowledge.
- To identify the list of contaminants that still require assessment criteria. Gaps will be highlighted and any data provided if available.
- To assess and test methods of deriving assessment criteria (i.e. background concentrations) as well as determining whether back-calculations of existing EQS (where these exist (2013/39/EU Priority substances Annex 1)) are appropriate.

WGMS will provide a final report, to include recommendations defining existing sediment guidelines, examples of approaches used, and will attempt to provide advice to support future MSFD and OSPAR status assessments.

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## BC values for PAHs in marine sediments in the Atlantic coast of Spain

**Lucia Viñas (IEO, ES)**

A PhD on BC values for parent and alkylated PAHs in sediments for the Atlantic Spanish coast has been presented recently.

Five areas in the Atlantic Spanish coast were sampled (including the Gulf of Cadiz), where sediment cores were collected to study their PAHs concentration. The analytical procedure involved pressurized liquid extraction (PLE) and gas chromatography coupled to mass spectrometry (GC/MS). The results obtained for the deepest layers of the cores provided adequate values to calculate BC. These values were determined, following ICES/WGMS 2005 Report, as the median value of the median concentrations from each of the five areas.

As a conclusion, 35 new BC values for 22 parental PAHs and 13 alkylated PAHs were presented that can be useful to improve environmental assessment criteria and that will be published in the next few months.

## 5.4 ToR D: Plastic litter

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ToR D - Assess the relevance and the potential risk impact of (micro-) plastics in sediments and follow up of outcomes of other expert groups	(Micro-)plastics are included in MSFD Descriptor 10, are of emerging concern and can be a vector for contaminant transfer to sediments, or from sediments to biota.	3 years	Annual updates and final report.
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Two presentations, one focusing on marine litter (SP) and one on microplastics (NO), were given updating the working group about current knowledge about the occurrence of microplastics in the aquatic environments with specific focus on current research efforts, gaps and future challenges. The abstracts are presented at the end of the section.

In the last decades, the increasing accumulation of plastic microliter in the aquatic environments has triggered the attention of both the scientific community and the public opinion. Governmental bodies, both at national and international level, have recently started to face such issue demanding scientists to develop effective tools to characterize levels and distribution of plastic debris in the environment (ICES, 2015). Over the last years scientists across Europe have focused on the development of standardized methods for sample collection, processing and detection of microplastics in several different environmental matrices, including marine sediments (Dehaut *et al.*, 2016; Inhof *et al.*, 2012; Loder *et al.*, 2015; Hidago-Ruz *et al.*, 2012; Van Cauwenberghe *et al.*, 2013; Karlsson *et al.*, 2017).

The activities and the main outcomes of some relevant for this topic EU projects such as JPI-O “Baseman”, JPI-O “Ephemare” and JPI-O “Plastox” have been introduced within the two lectures. To date, a range of different methods have been suggested to estimate the abundance, distribution and composition of microplastic in the marine environment showing different application limits, sensitivity and interval of applicability.

There is general agreement among all members of the WGMS about a substantial lack of standardized and unified collection of methods to support a comprehensive and reliable assessment of microplastics distribution in the benthic as well as all others environmental compartments. The assembly further agreed on the limited knowledge about the inter-related biological and chemical-physical consequences of the increasing accumulation of microplastics in sedimentary environment. Several recent findings have addressed that micrometric scaled plastic fragments can potentially act as vectors for pollutants enhancing both the accumulation on marine organisms as well as their physical dispersion from coastal to marine areas, as well as increase the bioavailability of hydrophobic pollutants co-occurring in the aquatic environment (Da Costa *et al.*, 2016; Gomiero *et al.*, 2018; Leon *et al.*, 2018; Pellini *et al.*, 2018). Due to the complexity of the discussed environmental issue, a multidisciplinary cooperation across different ICES working groups is advocated to release a harmonized collection of methods to quantitatively and qualitatively estimate the microplastics levels in sediments of the marine environments. The final goal for the addressed ToR will be a TIMES publication which aims at supporting the standardization of the analytical procedures, the production of good quality data to be used by environmental risk assessors to calculate thresholds levels, by toxicologists to set effective exposure concentrations in ecotoxicological studies and by environmental managers to support actions toward the restoration of plastic contaminated marine areas.

In its first year of the activity the implementation will focus on a networking phase where representatives of the ICES - Marine Chemistry Working Group (MCWG), the Biological Effects Working Group (WGBEC), the new Working Group on Marine Litter (WGML), the JPI-O Baseman, Ephemare and Plastox projects will be invited to discuss about the present ToR implementation and contribute in the 2019 ICES WGMS annual meeting.

In the second year of the ToR implementation the preparation of a review is scheduled as preparatory activities before to release the TIME document at the end of the third year (2020).

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### **Presentation: Microplastics in the aquatic environments: current efforts and future challenges**

**Alessio Gomiero, M. Arnberg, R.K. Beckmann, G. Skogerbø, K. Birger Øysæd**

Plastic waste is of increasing concern in the aquatic environment. A large portion of the plastic waste is produced onshore and reaches the marine environment, which is considered the main sink of plastic debris. Floating plastic particles accumulate in pelagic habitats. However, due to the biofilm formation they eventually sink and accumulate on the seafloor together with non-buoyant by design plastic particles posing risk to the benthic communities. There is, however, a considerable lack of standardized methods for microplastic particles occurrence and composition characterization. In the presentation, a benchmark among the best available extraction and detection technologies is introduced and a multitiered approach combining fast screening low resolution methods (tier 1) and sensitive analytical techniques (tier 2) is performed on a case study.

### **Presentation: LIFE-LEMA, Intelligent marine litter removal and management for local authorities**

**Oihane C. Basurko, Igor Granado, Luis Ferrer, Anna Rubio, Irati Epelde, Julien Mader, Jose Luis Asensio, Ivan Saez. 2018 (AZTI, ES). Presented by Maria J. Belzunce Segarra**

The Life LEMA project is part of the Environment and Climate Action LIFE European Program and aims to provide a methodological guidance and intelligent tools to the local

authorities for the effective management of floating marine litter in the southeast of the Bay of Biscay.

Life LEMA was approved in September 2016 and the project's tasks will run until September 2019. The project is made up by an international working group and has 6 partners led by the Deputy of Environment and Hydraulic works. The research centres AZTI and Rivages Pro Tech - Suez, the public organizations Syndicat Mixte Kosta Garbia and the town hall of Biarritz and the NGO Surfrider Foundation Europe complete the work team

In order to achieve the project's objective, a modelling of the technical, environmental and socio-economic aspects will be realized related to the floating marine litter of the Bay of Biscay. To achieve this goal, Life LEMA has a small fleet of ships that sample and collect floating marine litter, a floating barrier that will be placed at the river Deba (Gipuzkoa) to retain waste, drones, and thermal and video cameras located in the estuaries of the rivers Adour (Pyrenees Atlantiques) and Orío (Gipuzkoa) for the remote detection of floating marine litter, drift buoys and high frequency radars.

Life LEMA also wants to promote the search of common solutions for the management of marine litter in transboundary waters. Groups of experts from the cross-border geographic scope of the project (France and Spain) have been created, and through their participation in dynamic sessions, they will contribute to the improvement and monitoring of the European directives related to Life LEMA.

## 5.5 ToR E: Emerging issues

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ToR E1 - Review and inform on the occurrence of substances of emerging concern in sediments, including platinum group and rare earth elements, as well as organic contaminants	Sediments are a sink for many pollutants, but also can be a source.	3 years	Annual updates and final report.
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Results from the IMPACTA project in relation to contaminants of emerging concern were presented by Víctor M. León (IEO) and the results from a project on Platinum Group Elements by Juan Santos-Echeandia (IEO), as described below.

In the next two years, WGMS will aim to review the published data in relation to the occurrence, fate and biological effects of Contaminants of Emerging Concern (CECs) in marine sediments. It will not be possible to assess CECs that do not have any Sediment Quality criteria, so these will be noted under C (Sediment Quality Guidelines).

Members are encouraged to provide any further evidence in the next meeting, with the aim to provide an overview at the final meeting of this three-year term.

Contaminants of emerging concern (CECs) are substances present in the environment from a long time ago but the interest in their study has only recently been started, or from substances that are not well-known that are present in the environment due to their continuous input or to their pseudo-persistence. In order to identify the potential risk contaminants in the marine environment, the characterization of the main sources/inputs can be used or the study of occurrence and distribution in the marine environment. Attending to the origin of the sources, land and sea-based sources can be considered. Some

of the land sources can be Waste Water Treatment Plant (WWTP) effluents, industry effluents, river discharges, air deposition, etc. In the case of sea-based sources a review has been recently published (Tornero and Hanke, 2016) which list 276 substances from different sea-based sources such as shipping, mariculture, offshore activities, dredging, etc. There are many potential sources of contaminants, which can help to identify their origin and potential distribution: urban development, touristic activities, industry and transport, intensive agriculture, navigation and nautical activities, mining and other activities.

In the last decades many studies have been developed to characterize the occurrence and distribution of different groups of contaminants which can be considered of emerging concern, mainly in seawater. However, sediments can play an important role because they are a sink of many of these contaminants and consequently a potential source for marine organisms. It is also necessary to take into account that pressure and impacts are not continuous for many contaminants because significant seasonal changes in coastal areas for Current Use Pesticides (CUPs), pharmaceuticals, etc., (i.e.: sources, temperature and sunlight variations) and the heterogeneous distribution of sources in coastal areas (sources distance, hydrodynamic currents, dilution capacity, suspended solids sedimentation, etc.); (Gaw *et al.*, 2014 and references therein; Moreno-González *et al.*, 2015; Moreno-González and León 2017). Thus, less information is available from continental shelf and deep sea areas. Although some CECs can be present in sediments from many areas, probably it could be necessary to consider specific contaminants in every subregion or area depending on the predominant anthropogenic activities in each one.

Thousands of substances enter the environment but only few of them are included in the monitoring programs, and many of these substances are known to accumulate in sediments, with some of them provoking adverse effects on the marine environment. This information could be crucial in order to improve the assessment of the marine environment for Marine Strategy Framework Directive, Regional Conventions, and for national requirements.

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### **Presentation: Contaminants of emerging concern in sediments from the Spanish continental shelf**

**Víctor M. León, Gloria Grueiro, Juan A. Campillo, Victoria Besada and Soledad Muniategui-Lorenzo.**

The occurrence and distribution of personal care products (PCPs: synthetic musks, UV filters and antimicrobial agents) and current-use pesticides (CUPs: organophosphorus, triazines, etc.) were characterized in surface sediments from 12 areas along the Spanish Mediterranean continental shelf through the IMPACTA project (CTM2013-48194-C3). The distribution of CUPs and PCPs was heterogeneous and depended on the predominant activities in each coastal area (industrial, touristic, agricultural, etc.) and other factors, such as the distance to main pollutant sources, the hydrodynamic currents, the dilution from sources, the suspended solids deposition rates, etc. 20 of 49 considered contaminants were found in some of the sediment samples. PCPs were found at the highest concentrations in nine of the studied areas and triazines were the most abundant ones in three areas. Considering individual compounds, the synthetic musks (tonalide and musk ketone), the plastic additive tributylphosphate and the insecticide chlorpyrifos were found in all studied Mediterranean continental shelf sediments. However, other compounds were found only in some areas at high concentrations (i.e.: triclosan, galaxolide) showing the influence of specific human activities in these cases. Then, the influence of recreational, urban development and agriculture activities has been evidenced along the Spanish Mediterranean continental shelf, but further studies will be required in order to assess the bioavailability and the potential impact of the contaminants found in sediments on marine organisms.

### **Presentation: Technology Critical Elements (TCEs)**

**Juan Santos Echeandía, Antonio Cobelo García, Clara Almécija Pereda, Patricia Neira del Río**

Technology critical element concentrations (Ga, Ge, In, Nb, Ta, Te, Tl, the platinum group elements (Ir, Os, Pd, Pt, Rh and Ru), and most of the rare earth elements (Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Y and Yb)) are increasing in the environment during the last years as seen both in biota and sedimentary compartments. The analyses carried out in mussel tissues from the IEO pollution monitoring program showed an increase trend of Pt concentrations after 1995. In contrast, this study showed concomitant decreased levels of Pb concentrations. These trends are related with the use of Pt in the catalytic converters of the cars. Therefore these results pointed out that more attention should be paid in the next years in order to check if TCE levels continue to increase and can pose an ecological risk for the environment. However TCEs are not included in the different directives but may be in a near future they should.



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ToR E2 - to consider other forms of pollution, e.g. microbiological	Sediments are a sink for many pollutants, but also can be a sink.	3 years	Annual updates and final report.
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The presence of asbestos in sediments was considered as another form of pollution in sediments. While this is naturally occurring and of low risk to the environment, it is an important consideration when marine sediments are dried, for example, in laboratory analyses.

**Presentation: Asbestos in sediments**

**Claire Mason and David James, Cefas**

Low levels of asbestos have been found in ~20% of marine sediments tested, mainly from ports and harbours, in England and Wales. The main risk of asbestos exposure is when samples are dry, and the asbestos fibres can become air borne. EU regulations (Directive 2009/148/EC) impose a Control Limit for airborne asbestos, but there are no safe levels of asbestos, and so although levels are low (<0.1% hazardous waste limit), awareness of this potential risk is important, particularly in relation to laboratory processes where samples are dried.

Individual laboratories are encouraged to risk assess laboratory procedures in relation to presence of low levels of asbestos in samples and train staff as required. This work was also presented at MCWG by Philippe Bersuder.

WGMS has determined that while asbestos is a known contaminant, the presence of asbestos within marine sediment should be viewed as a contaminant of emerging concern. Claire is leading a Cefas publication, combining data presented here with data gathered by Marine Scotland. This publication will be included as an output within the current 3-year WGMS programme.

Other relevant emerging issues can be related with trace metals, such as the platinum group due to their increasing use in many industrial applications.

**5.6 ToR F: Impact of renewable energy devices**

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ToR F - Explore the potential risk impact in terms of inputs (corrosion, anti-corrosion agents...) and release of contaminants due to sediment scouring	Changes in hydrodynamics may release sediment-bound contaminants; there may be inputs of contaminants during installation, operation and decommissioning. This is under active research by a member of the group.	3 years	Report (with recommendations, as appropriate)
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This is under active research by a member who has not been able to attend this WGMS meeting. A project looking at emissions from corrosion protection systems of offshore wind farms (presented at WGMS 2017 meeting) has just started, and it is hoped it will be possible to include results from this work within the three-year programme. In summary,

this project aims to understand what the potential impacts to the marine environment are from corrosion protection systems.

A report (Copping, A., Sather, N., Hanna, L., Whiting, J., Zydlewski, G., Staines, G., Gill, A., Hutchison, I., O'Hagan, A., Simas, T., Bald, J., Sparling C., Wood, J., and Masden, E.2016. Annex IV 2016 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World) was reviewed during the 2018 meeting and it is noted that this report concludes that 1/ numerical models provide evidence that Marine Renewable Devices (MRDs) will have minimal effects on hydrodynamics locally, as well as for larger scale developments. The report recommends validation of models with real data, particularly for larger scale developments. 2/ Chemical effects of MRDs are relatively low risk as commercially available paints/coatings have already undergone rigorous testing, and any releases are likely to be short term, for example, as result of a spill.

Members are requested to provide evidence from any projects/studies to evolve these conclusions further, if possible.

There is limited contaminant data available from muddy sediments by request from the UK Marine Management Organisation (MMO) public register, which may be useful for determining marine environmental impacts, although generally contaminant analysis of seabed samples are not requested for licensing applications related to wind farm developments. This is because the sediment is not being removed from the environment, and as indicated in the previous reference, numerical models indicate minimal hydrodynamic changes will occur, so sediments will remain in the local area.

There are hydrodynamic assessments being completed at a few test sites in England and Wales to determine potential changes that may occur as a result of tidal and wave devices. Information from this work will be provided when available.

In addition, Cefas are looking to undertake a review of chemicals used at offshore wind farms for England and Wales and information from this work will be provided when available.

## 5.7 ToR G: Passive sampling

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ToR G1 - Publish guidelines on passive sampling on sediments.	Documents are in advanced drafts and will be completed.	1 year	Two ICES TIMES paper
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Resolutions for ICES publications were approved at the 2017 Annual Science Conference. With the remote contributions of three authors, good progress was made towards the completion of a Techniques in Marine Environmental Science (TIMES) paper on passive sampling of metals in sediments and a second paper on hydrophobic contaminants. It is expected that they will be complete for internal review by autumn 2018 and will be submitted for publication by the end of March 2019.

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ToR G2 - Publish a review on passive sampling techniques.	A review document is at an advanced stage of drafting and will be completed.	1 year	Cooperative Research Report
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A resolution for this ICES publication was approved at the 2017 Annual Science Conference. With the remote contributions of 3 authors, good progress was made towards the completion of a Cooperative Research Report on passive sampling of sediments. It is expected that this document will be complete for internal review by autumn 2018 and will be submitted for publication by the end of March 2019.

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ToR G3 - Review and update on developments	Passive sampling is an advancing area of research that could improve on existing monitoring techniques	3 years	Annual updates and final report
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A presentation was received from an INTERREG project on the development of Environmental Quality Standards for passive sampling of waters was presented.

### **Presentation: MONITOOL**

#### **M.J. Belzunce (AZTI, ES)**

MONITOOL is a European project consisting of 16 Partners covering the Atlantic region from the Canary Islands to the Scottish Highlands and Islands, which aims to respond to European Directive demands for the assessment of the chemical status of transitional and coastal waters. Diffusive Gradient in Thin Films (DGT), and passive samplers (PS), in general, are already widely used in investigative monitoring and there is an increasing interest in their use for the environmental assessment of water bodies, within European policies requirements. The main barrier hindering the regulatory acceptance of PS for compliance checking is the lack of appropriate Environmental Quality Standards (EQS). EQSs for metals are defined in the dissolved fraction, preventing the use of DGT-labile concentrations for the establishment of the chemical status of water bodies. Thus, the main objective of MONITOOL is to adapt the existing EQSs to DGTs, enabling the use of DGTs for regulatory monitoring. The fulfilment of the overall objective will be achieved by organizing two different campaigns, in winter and summer, which consist in the simultaneous deployment of DGTs and the high-frequency collection of spot water samples. The first sampling campaigns were performed during winter 2017/2018 in four selected sites (transitional and coastal sites) in each consortium region (8 regions). All partners followed the same protocol for sampling and analysis to minimize the operational variability. Priority metals (Cd, Ni, Pb) and other specific metals (Al, Ag, Cu, Cr, Co, Fe, Mn, Zn) will be analysed in waters and in the DGT resins. Statistical analysis will be applied to study relationships between metal concentrations in DGT and in spot water samples. In a final step, suitable EQS for DGTs will be calculated on the basis of the statistical relationships obtained previously. This will permit a better implementation of the Water Framework Directive in high variable systems like transitional and coastal waters. The advantages of this implementation will be analysed in terms of cost/effectiveness of the sampling programs, representativeness and reliability of the results.

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ToR G4 - Continue to develop a database to provide information of use in developing assessment criteria for passive sampling techniques	3 years	Dataset and advice to OSPAR on progress
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No progress was made on this ToR.

## **6 Revisions to the work plan and justification**

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No revisions are required.

## **7 Next meetings**

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WGMS will next meet at the University of Evora, Portugal, on 4–8 March 2019.

## Annex 1: List of participants

Name	Institute	Country (of institute)	Email
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## Annex 2: Review and suggestions about the management of dredging activities

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Rita Fonseca (Univ. Evora, Portugal), Carla Palma (Instituto Hidrografico, Portugal),  
Claire Mason (Cefas, UK)

### 1. Standardization of guidelines for the management of dredged sediments

#### Background

Different national guidelines are in use for the management of dredged material in the countries of EU. The framework for these guidelines is given by international conventions, like the London Convention (LC) 1972, the Oslo-Paris Convention (OSPAR) and Helsinki Convention (HELCOM). The implementation and the setting of assessment criteria are within the custody of each country. Hence, there are differences concerning the assessment criteria for the material to be disposed at sea. All countries make use of guidance levels and/or threshold levels for the characterization of dredged material. Thus, it is difficult to compare the guidelines adopted by the different European countries because they have adopted distinct: (1) elements and organic compounds, which should be necessarily analysed, (2) threshold values, (3) action levels, (4) grain size fractions where metals and organic compounds are analysed.

There are countries, for example, that have only 3 action levels, while there are others that follow more strictly the rules indicated by OSPAR and that have 5 levels.

Netherlands is the only country who was adapted 1 action level for each element or compound. These values are given as threshold or guidance levels. Threshold values are given for priority substances, which are mostly organic contaminants but also selected metals. These values are treated as strict limit values without exceptions. For non-priority substances an exceedance of up to 50% is tolerable as long as it only concerns 2 substances.

The action levels, besides being different among the several countries, are derived on distinct physico-chemical bases:

- 1) Background concentrations (Netherlands)
- 2) Sediment contaminant concentration (Germany)
- 3) Ecotoxicological bases. These values have been evaluated using bioaccumulation functions for seabirds and humans (Belgium, Norway)
- 4) Background concentrations in the first level and global toxicity of sediments in the 2nd level (France, UK, Ireland, Denmark).

In relation to the list of elements to be analysed, there is uniformity with respect to the metal and metalloid elements that are to be analysed (As, Cd, Cr, Cu, Ni, Pb, Zn, and Hg). However, the regulations in a few countries adopt a high number of organic compounds, separating some organic groups (e.g. PAHs) into a higher number of components. This is the case of Norway who analyse 16 PAHs compounds and 7 PCBs, along with a list of less common organics, following the OSPAR list of chemicals for priority

action, which are not analysed by the other European countries. Most countries prioritise the monitoring of 10 PAHs and 7 PCBs.

One of the greatest differences between the values adopted by each country is that in the most countries these values are referring to dry solids and apply to total samples in the grain size fraction < 2 mm (Netherlands, Belgium, France, UK, Ireland, Denmark, Norway, Spain, Portugal), while in Germany the selected fractions depends on the nature of the elements/compounds: metal standards are referring to the grain size fraction < 20 µm, organic parameters are referring to the fraction < 63 µm, except TBT which is applied to the total fraction (all referring to dry solids). This finer, higher surface area, clay-rich fraction often has a higher proportion of both anthropogenic and natural metals, and organic matter, so these values may not be directly comparable to those based on the coarser fraction.

Also the extraction procedures are quite different which invalidates the comparison between the concentrations obtained for each element. There exist three different extractions for the metals analysis which, obligatory, have different meanings: a few countries adopted a total extraction using a tri-acid digestion (HF-HNO<sub>3</sub>-HCl), for example Belgium, France, Ireland and Norway, while others use partial digestions for the metals release: HCl-HNO<sub>3</sub>, or HNO<sub>3</sub>.

The differences in guidance criteria existing among the European countries from the OSPAR region are summarized in Tables 1, 2 and 3, extracted from a review and compilation of the chemical action values by Cefas and SEA Environmental decision (Marine Management Organization, 2015).

Given these considerations it is obvious that all these differences have the potential to affect the threshold levels for the characterization of dredged material and it is clear that it is difficult to compare different national values for the same parameter and any comparisons between them must be viewed with caution. In a strict sense a direct comparison of national action levels / standards between different countries cannot be made.



Table 1: Summary of OSPAR country Chemical Action Levels (cAL1). Extracted from chemical action values by Cefas and SEA Environmental decision (Marine Management Organization, 2015).

	Action List	Units	BLG	DK	FIN	FR	GER	IRE	NL	NOR	POR	SP	UK
Metals	Arsenic	mg/kg	20	20	15	25	40	9		52	50	80	20
	Cadmium	mg/kg	2.5	0.4	0.5	1.2	1.5	0.7		2.6	3	1	0.4
	Chromium	mg/kg	60	50	65	90	120	120		560	100	200	40
	Copper	mg/kg	20	20	50	45	30	40		51	150	100	40
	Mercury	mg/kg	0.3	0.25	0.1	0.4	0.7	0.2		0.63	1.5	0.6	0.3
	Nickel	mg/kg	70	30	45	37	70	21		46	75	100	20
	Lead	mg/kg	70	40	40	100	90	60		82	150	120	50
	Zinc	mg/kg	160	130	170	276	300	160		360	600	500	130
Organotins	Tributyl tin	mg/kg	0.003	0.007	0.003	0.1	0.02	0.1		0.005			0.1
	Tributyl Tin - WS	mg/kg					0.02						
PCBs	PCB - total	mg/kg	2µg/g ΣICES7	0.02 ΣICES7		0.5 ΣPCB	0.013 ΣICES7	0.007 ΣICES7		0.017 ΣICES7	0.025 Σunknown	0.03 ΣICES7	0.01 ΣICES7 0.02 Σ25PCB
	PCB 28	µg/kg			1	25		1					
	PCB 52	µg/kg			1	25		1					
	PCB 101	µg/kg			4	50		1					
	PCB 118	µg/kg			4	25		1					
	PCB 138	µg/kg			4	50		1					
	PCB 153	µg/kg			4	50		1					
PCB 180	µg/kg			4	25		1						
Hydrocarbons	Total hydrocarbons	mg/kg					200	1000					100
	Mineral oil	mg/kg			50								
	tPAH	mg/kg	14µg/g 70µg/g Σ10PAH	3 Σ9PAH			1.8 Σ16PAH	4 Σ16PAH		2 Σ10PAH	2 Σ10PAH		
	Acenaphthylene	mg/kg				0.1							
	Anthracene	mg/kg			0.01	0.5							
	Benzo[a]anthracene	mg/kg			0.03	0.7							
	Benzo[a]pyrene	mg/kg			0.3	0.2							
Benzo[a,h]anthracene	mg/kg				0.1								

	Action List	Units	BLG	DK	FIN	FR	GER	IRE	NL	NOR	POR	SP	UK
	Benzo[b]fluoranthene	mg/kg				0.3							
	Benzo[g,h,i]perylene	mg/kg			0.8	0.15							
	Benzo[k]fluoranthene	mg/kg			0.2	0.15							
	Chrysene	mg/kg			1.1	1							
	Fluoranthene	mg/kg			0.3	0.4							
	Fluorene	mg/kg				0.2							
	Indeno[1,2,3-c,d]pyrene	mg/kg			0.6	0.2							
	Naphthalene	mg/kg			0.01	0.2							
	Phenanthrene	mg/kg			0.05	1							
	Pyrene	mg/kg				1.5							
	α-HCH	µg/kg											
	γ-HCH (Lindane)	µg/kg											
	Dieldrin	µg/kg											
	HCB	µg/kg											
	Pentachlorobenzene	µg/kg											
	p,p'-DDT	µg/kg											
	p,p'-DDE	µg/kg											
	p,p'-DDD	µg/kg											
	Σ DDT, DDE, DDD	µg/kg											
Analysis methods	Sediment fraction analysed		<63µm	<2mm		<2mm	<20µm metal, <63µm organic	<2mm	<2mm	<2mm		<63µm	<2mm
	Extraction technique - metals		Total - HF			Total - HF		Total - HF	Partial HNO <sub>3</sub>	Total - HF		Partial HNO <sub>3</sub>	Partial HNO <sub>3</sub>
	Extraction technique - organics		Solvent						Solvent	Solvent		Solvent	Solvent

Country acronyms: BLG – Belgium, DK – Denmark, FIN - Finland, FR – France, GER – Germany, IRE – Ireland, NL – Netherlands, NOR – Norway, POR – Portugal, SP – Spain and UK – United Kingdom



	Fluoranthene	mg/kg			3	5							
	Fluorene	mg/kg											
	Indeno[1,2,3-c,d]pyrene	mg/kg			6	1							
	Naphthalene	mg/kg			0.1								
	Phenanthrene	mg/kg			0.5								
	Pyrene	mg/kg											
	$\alpha$ -HCH	$\mu\text{g}/\text{kg}$					1.5	1.0					
	$\gamma$ -HCH (Lindane)	$\mu\text{g}/\text{kg}$					1.5			2.2			
	Dieldrin	$\mu\text{g}/\text{kg}$											
	HCB	$\mu\text{g}/\text{kg}$					5.5	1.0	20	61	50		
	Pentachlorobenzene	$\mu\text{g}/\text{kg}$					3			800			
	$p,p'$ -DDT	$\mu\text{g}/\text{kg}$					3						
	$p,p'$ -DDE	$\mu\text{g}/\text{kg}$					3						
	$p,p'$ -DDD	$\mu\text{g}/\text{kg}$					6						
	$\Sigma$ DDT, DDE, DDD	$\mu\text{g}/\text{kg}$			30				20	490			
Analysis methods	Sediment fraction analysed		<63 $\mu\text{m}$	<2mm		<2mm	<20 $\mu\text{m}$ metal, <63 $\mu\text{m}$ organic	<2mm	<2mm	<2mm		<63 $\mu\text{m}$	<2mm
	Extraction technique - metals		Total - HF			Total - HF		Total - HF	Partial HNO <sub>3</sub>	Total - HF		Partial HNO <sub>3</sub>	Partial HNO <sub>3</sub>
	Extraction technique - organics		Solvent						Solvent	Solvent		Solvent	Solvent

\*0.139 = correction for  $\Sigma$ ICES7, original value 0.2  $\Sigma$ 25PCBs

Country acronyms: BLG – Belgium, DK – Denmark, FIN - Finland, FR – France, GER – Germany, IRE – Ireland, NL – Netherlands, NOR – Norway, POR – Portugal, SP – Spain and UK – United Kingdom

### Conclusions

To have a uniformity in the action levels of the pollutants of the dredged sediments, and in order to allow a direct comparison between different countries, it is suggested that all the countries of EU adopt the same standards based on the same physic-chemical basis:

- (1) Priority elements and organic compounds should be the same,
- (2) the threshold values should be the same, divided in the same number of action levels (3-5),
- (3) metals and organic compounds should be analysed in the whole sediments in the grain size below 2 mm,
- (4) Considering that the different countries have distinct geological settings which affect sediment metal and metalloid concentrations, equal concentrations found in distinct geological settings do not have the same significance as contaminants. For example, the Norwegian chromium values appear extremely high compared to all other countries possibly due to high chromium mineralisation in Norwegian rocks. Thus, for these hazardous elements the action levels should be normalized values in relation to the geological background for each element. These values could represent an enrichment factor which has to be tested in different countries in order to find a general formula adapted to all geological conditions,
- (5) Since the analytical methodologies could influence data, it would be important to have standardized methods of extraction and analysis.

## 2. Problems of the metals solubility in the dredging operations

### Background

Sediments are the ultimate reservoirs of contaminants originating from urban, agricultural, and industrial lands and recreational activities and contaminated sediments in rivers and streams, lakes, coastal harbours and estuaries have the potential to pose ecological and human health risks.

Over time, dredger operations have developed containment, treatment and disposal technologies to handle these wastes, and thus clever engineering solutions have been developed and applied. However, costs became higher and options were restricted (Apitz, 2006).

Contaminants transfer between all environmental media and to reduce risk, we must assess and manage them holistically and at all the scales. Sediment is part of the hydrodynamic continuum and any action on a sediment unit can affect other parcels, resulting in conflicting, counterproductive or inefficient management actions if not coordinated.

Metals present in sediments can be strongly retained in the structure of silicate minerals, oxides or sulphides, or they may be weakly bound to the surface of clay minerals and organic particles by adsorption or fixation; they can also exist as soluble phases in pore water. The latter forms have a high mobility and, although a few metals do not have their

most toxic forms in the soluble phase, they generally represent the most hazardous forms of metals in the environment due to their easy transfer to the water column and hence their bioavailability. Metals associated to silicate and oxides are the least mobile and represent the most part of metals with lithogenic origin and the most immobile forms. Metals in sulphides are often insoluble, but still represent an environmental risk since they can easily oxidize if they are disturbed, releasing metals to the water column.

The main measures for the remediation of contaminated sediments undergo joint control strategies at source and recovery or containment through the application of in situ or ex situ removal, containment and treatment measures, the applicability of which depends not only on the nature of the contaminants, but also the intrinsic characteristics of the sediments. Knowledge of the complexity involved in processes that stimulate the mobilization of heavy metals is the basis for the design of remediation methodologies. Mobilisation of metals is influenced by many factors; some physicochemical conditions may be effective for the release of certain metals from binding phases but result in the immobilization of other metals. The response of metal elements to these factors has to be taken into account during the planning of a remediation project (Fonseca *et al.*, 2015).

Dredging is considered to be one of the most efficient techniques with permanent or long lasting results in terms of increasing the assimilation capacity of a water body, being the only technique able to remove all or part of the sediments, a preferred site of accumulation and retention of metallic elements, nutrients and other organic pollutants (MACTEC Project, 2008). One of the great advantages with regard to chemical or biological remediation methods is that it does not contribute to the introduction into the system of foreign substances (U.S. EPA, 1981; Alan Plummer Associates, 2005). However, their effectiveness depends on prior control of the material being leached from the basin by implementing efficient techniques for minimizing the transport of particulates and soluble elements to the water lines.

No remediation method can remove, contain or treat contaminated sediment materials without any disturbance and consequent release of contaminants. In the case of dredging, even using the most environmentally correct methodologies there is always a resuspension of sediments in the water column. In addition to the dredging processes, also the transport of these contaminated sediments can lead to some losses and dispersion of material, introducing contaminants in previously decontaminated areas. The risk associated with this resuspended material depends on the physicochemical characteristics of the sediments, the nature of the metals and their geochemical behaviour when modifications of the chemical conditions of the environment occur, namely modifications of pH and redox conditions (Fonseca *et al.*, 2015). Many of the metals accumulated in sedimentary materials increase their mobility under oxidizing conditions. These elements are generally associated with the mineral particles of the sediments at their deposition sites in the reduced state. Any reclosing of the material caused by the dredging leads to an increase in oxidizing conditions, increasing the solubility of metals and consequently increasing their concentration in the water column.

European guidelines for the management of dredged material in the countries of the EU do not include assessments of the major binding phases (e.g. oxyhydroxides, sulphides, organic matter) which influence the partitioning, mobility, and bioavailability of metals in sediment. Threshold or guiding levels are based on total concentrations, and thus do not take into account factors influencing metal bioavailability in sediments. During

dredging operations, there is often high levels of resuspension of the smaller and less dense particles, in parallel with the release of the most soluble or labile species, which can pose numerous environmental problems. Thus, these action levels do not represent the real environmental hazard of the metals in the sediments and, especially, the problems that may arise due to their possible release during dredging operations.

### **Conclusions**

In order to avoid any problems that may occur during dredging operations, to reduce or prevent the resuspension of sediments and the mobility of metals, the common used dredging mechanisms should be reviewed by using more environmentally friendly dredges and there should be an extensive knowledge of the chemical behaviour of the metallic elements present in the sediments.

Thus, this working group propose the following suggestions:

- 1- The dredging operation should be cautioned and the cutting edge of the equipment should be monitored, in order of avoiding high levels of sediment resuspension;
- 2- In the case of fine-grained sediments, the dredging operation, should be accomplish by silt curtains which are floating barriers, made in PVC or geotextiles, designed for in-water control of turbidity during dredging activities;
- 3- There should be a greater knowledge about the chemical behaviour of metals, owing the possibility of being released to the water column during the dredging activities. Considering that the ability to solubilize depends on the nature of the organic and mineral compounds where they are associated, it is imperative that the guidance and threshold values include the total contents of each metal, and the contents of its available forms.
- 4- The monitoring programs should be better schedule, with periodic and complete checks of the water quality before, during and after the dredging operation (as already regulated), but with a tighter control. These programs should include all the elements and compounds that are above the threshold values and the elements that can increase their solubility under oxidizing conditions or the ones that are in the sediments in more soluble phases.

### **3. Reuse of the dredged sediments**

#### **Background**

Sediments act as a sink and also as a source of many hazard substances, including heavy metals and organic compounds with anthropogenic origin. However, they also represent a reservoir for many other elements and compounds coming from the weathering of rocks and soils from the drainage areas, which could be useful if correctly extracted and reused. Among these elements/ compounds it could be found phosphorus and nitrogen in high levels that may be harmful to the water quality considering their role as key elements for eutrophication. However, once the sediments are extracted, they may represent

a good option for the fertilization of agricultural soils, if they do not have potentially toxic elements above critical levels and if they are extracted in freshwater systems or in coastal area under the influence of river waters.

Other elements that can be accumulated in sediments are the emerging elements, with great demand worldwide, due to its high economic value, their occurrence with very low levels in the nature, even in mineralized zones and the multiple uses in the industry. The most in-demand emerging elements include those from the platinum group (Au, Pt, Pd, Ru, Os, Ir), indium (In) and the rare earth elements (REE). Among these elements, the majority of REE and In have lithogenic origin, and can be release from the host-minerals by chemical and physical weathering and due to their chemical resistance they can be transport to long distances without any significant alteration. This is the reason why rare earth elements are commonly used to study the sediments provenance. Elements from the platinum group has as their main source mineralization as sulphides, but they also have an anthropogenic origin, from automotive catalysts and the effluents from a few industries. These emerging elements subsequently reach the ocean and they can be found in sediments accumulated in rivers, estuaries and coastal areas.

### Conclusions

During the phase of the recognition of the area and evaluation of the pollutants levels, it could be included analysis of the contents of the emerging elements, especially if the area to be dredge is feed by an ore mining zone or an intensely populated area, in order of evaluating the possibility of reuse those elements from the dredged sediments.

If the concentrations of these elements are significant and if a study of the evaluation of their extraction from the dredged sediments shows its reuse to be economically advantageous, it may be possible to reduce the costs inherent of dredging processes, which are always very high.

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