WORKSHOP ON THE ROLE OF ECOTOXICOLOGICAL DATA IN SEDIMENT QUALITY AND DREDGED MATERIAL ASSESSMENT FRAMEWORKS

1-2 OCTOBER 2020

INTRODUCTION

Many hazardous substances accumulate in sediments and may cause adverse ecological effects in situ and – if taken out of the system – ex situ. When their concentrations exceed the respective national regulation, they tend to increase dredged material management costs.

It has been suggested to put more emphasis on the effects that chemicals have rather than to focus solely on concentration data. In current European national regulations, however, the extent to which information on ecotoxicological effects are used in sediment quality and dredged material assessment ranges from "none" to "being an equally important line of evidence".

In this workshop, people from academia, regulatory bodies and harbour authorities were invited to discuss experiences, challenges and approaches regarding the use of biotesting and ecotoxicological data in assessment and decision frameworks.

Specifically, the following research questions were addressed:

Topic A - The application of ecotoxicological testing in sediment quality and dredged material assessment frameworks

Topic B - Sediment quality criteria and their efficiency to protect the environment and its living resources.

Topic C - Deriving sediment quality guidelines against the background of the European Water Framework Directive

Topic D - Applicability of passive sampling methodology to derive thresholds suitable for assessment purposes

ORGANIZERS

Claire Mason, CEFAS (UK)

Claire Mason has over 20 years of experience working as a marine sedimentologist. Within this time Claire has successfully led numerous projects which include research into regional trace metal baselines around the UK, as well as standardization of particle size methodology. She is the particle size contract leader for the North east Atlantic Marine Biological Analytical Quality Control Scheme. Claire co-chairs the ICES Working group for Marine sediment in relation to Pollution, and currently sits on the British Standards Water Quality Sampling committee. Currently she is leading an action levels review project for the UK, looking at implications of possible scenarios in terms of number of samples affected, as well as looking at inclusion of new evidence such as ecotoxicology as part of future sediment management framework.

Susanne Heise, Hamburg University of Applied Sciences (DE)

Susanne is a biological oceanographer by education, and specialized on aquatic ecotoxicology with a strong focus on sediments. However, most her work for the last 15 years has been on freshwater rather than on marine environments, with the Elbe River and the Port of Hamburg being so close. She has been a member of the European Sediment Network (SedNet) since it started in 2002 and co-chairs the SedNet work group on sediment quality together with Carmen Casado of the Ecotox Centre in Switzerland. She also coordinates the WP3 of the Interreg Project Sullied Sediments. At the HAW, Susanne leads the research group on applied aquatic toxicology. Current topics in her basic research are ecotoxicology of rare earth elements in aquatic systems and the effect of nano-cocktails (nano-TiO2 and Cadmium) on invertebrates. Her applied research focuses on sediment classification systems for dredged material management.

Carmen Casado, Swiss Centre for Applied Ecotoxicology (CH)

Carmen is a marine scientist by education specialized on sediment ecotoxicology, with a PhD on the use of sediment quality guidelines and toxicity tests for the characterization of dredged material intended for open water disposal. She moved from marine to freshwater sediments in 2012, when she joined the Swiss Centre for Applied Ecotoxicology. She is coordinating the project for the development of a strategy for sediment quality assessment in Switzerland. She has been involved in assessing sampling strategies for sediment monitoring, in the derivation of sediment quality criteria for traditional and emerging pollutants, and the use of sediment toxicity tests for sediment quality assessment. Member of SedNet Steering Group since 2013, she co-chairs the work group on sediment quality together with Susanne Heise.

EXPECTATIONS

Claire:

My interest in this workshop is primarily to learn more about how ecotoxicology methods are used for dredge assessments to inform work in the UK I am leading to develop a dredge sediment assessment/management framework. We have just completed a review of UK action levels and have proposed updated action levels for dredge sediment assessment. The next step is to create a framework for stakeholders. Ecotoxicological testing is not part of our current assessment process, although it can be completed to provide further evidence to help with decision making. I am interested in how WFD requirements can be better aligned and included within the new framework. As co-chair for the **Ices Working group for Marine Sediments**[1], I am interested in understanding what future work we should be proposing to support what we define as future requirements during this workshop.

Susanne:

On my opinion, ecotoxicological tests have a large added value when applying them in sediment management, compared to basing decisions on chemical concentration data alone. The approaches to interpret chemical and ecotoxicological data, however, are different, which sometimes leads to misconceptions. And there are also still a lot of methodological and conceptual challenges to be dealt with, when basing costly decisions on ecotoxicological data. My expectation from this workshop is, to bring people with different backgrounds together and exchange ideas on how to approach some of these challenges in a jointly effort in order to move – step by step – to environmentally safer decision making frameworks.

Carmen:

My expectations for the workshop are the exchange of experiences, knowledge, and results of case studies on the four topics of the workshop. Ideally, the workshop will help in finding consensus among sediment experts on the way forward for overcoming the challenges faced for implementing sediment quality and monitoring strategies (e.g. uncertainty in sediment quality guidelines derivation, sediment quality classification system, integration of sediment toxicity test results in a sediment quality classification system, communication of uncertainties to stakeholders and environmental agencies).

[1] http://www.ices.dk/community/groups/Pages/WGMS.aspx),

PARTICIPANTS

Sabine E. Apitz, SEA Environmental Decisions, Ltd. (UK)

With a BS in chemistry and a PhD in oceanography/marine geochemistry (SIO 1991), Sabine has been working in a range of aspects of the ecosystems-based assessment, management and regulation of marine and terrestrial ecosystems, with an emphasis on sediments (contaminated and uncontaminated) for more than 30 years in academic, government and business sectors. Sabine specialises in the innovative integration of scientific and decision tools in support of evolving stakeholder and policy frameworks and objectives. Her work focuses on the evolving question of how we transparently and meaningfully use cross-disciplinary science to more sustainably evaluate and manage human impacts and demands on ecosystems. Sabine participated in two SedNet WGs when it started in 2002; contributing to the summary books and papers, and has contributed to SedNet workshops and meetings since. She is a Deputy Editor of the journal Integrated Environmental Assessment and Management.

Antonella Ausili, Italian Institute for Environmental Protection and Research ISPRA (IT)

My name is Antonella Ausili and I'm chemist. I previously worked at Laboratory of Applied Toxicology of the Italian Institute of Health in order to develop a research dealing with the presence of pesticides and other organic contaminants in waters, sediments and marine organisms and since 1991 I'm working at ISPRA (formerly ICRAM) as senior Researcher. My research activity is concerning the chemistry of organic compounds (mainly PAHs, pesticides and PCBs) in different matrices, and the related problems in restoration projects, dredging and mobilisation of marine sediments, evaluation of environmental quality in contaminated marine sites. In addition, I also interested in ecotoxicology. I have been responsible of numerous research projects and I was author/co-author of several scientific peer review paper. I also gave support to Italian Ministry of Environment for the evaluation of marine environmental impact due to anthropogenic activities.

Agnieszka Baran, University of Agriculture in Krakow (PL)

Agnieszka is associate professor at the Department of Agricultural and Environmental Chemistry, specialized on ecotxicology and environmental chemistry. Her main research focuses on the content, bioavability and ecotoxicity of trace elements in bottom sediments form freshwater environments and soils. Most her work has been on properties, quality assessment and the possibility of managing the bottom sediments dredged from dam reservoirs. Other topics in her research are chemical properties of food products, agricultural waste utilization and health risk assessment. Currently she leading the project "Assessment of the bottom sediment organic matter on bioavailability and toxicity of chemical compounds". At the university, she mainly teach the following courses: Ecotoxicology, Environmental chemistry, Agricultural chemistry, Audit and environmental standards.

Rébecca Beauvais, Swiss Centre for Applied Ecotoxicology (CH)

Dr. Rébecca Beauvais is an ecotoxicologist at the Swiss Centre for applied ecotoxicology in Lausanne (Switzerland) since September 2019. She works on the development and standardisation of methods for the assessment of sediments in Switzerland in biomonitoring purposes and the use of transcriptomic biomarkers in ecological assessment of sediments. She studied biology and ecology in France. In her PhD thesis at University of Geneva, she investigated the use of transcriptomics to assess mercury bioavailability in primary producers.

Juan Bellas, Spanish Institute of Oceanography IEO (ES)

Juan Bellas has a PhD in Marine Sciences, specializing in ecotoxicology and marine pollution. He is Professor of Research at the Spanish Institute of Oceanography (IEO). He is the Chief Investigator of the Marine Pollution Program of the IEO, and he was Coordinator of the scientific activities for the

implementation of the Marine Strategy Framework Directive in Spain from 2010 to 2018. He has participated in various international committees and working groups of the European Commission, groups of the OSPAR Commission and of the International Council for the Protection of the Sea (ICES). He is currently Chairman of the ICES Working Group on Biological Effects of Contaminants (WGBEC). He is an advisor to the Ministry of Ecological Transition of Spain, and is a member of the UNESCO Chair in Sustainable Littoral Development (Campus do Mar). He has made research stays in several universities and research centers in the United States, Australia, Sweden and Iceland. He has participated in several oceanographic cruises, including 3 cruises in Antarctica. He has participated in more than 30 projects and research contracts (leader in 10), and has published 62 articles in SCI journals, and several book chapters, on the study of the biological effects of pollutants and the integrated assessment of marine pollution. He has been granted three patents, on the use of embryo-larval bioassays for the evaluation of the efficacy of antifouling compounds, on the cryopreservation of sea urchin embryos, and on a submergible mussel-caging device for marine pollution analysis.

Maria Jesus Belzunce Segarra, Marine and Coastal Environmental Management AZTI (ES)

PhD in Chemistry by the University of Mining and Metallurgy, Kraków (Poland). She works in AZTI in the Marine Research Division since 1998. Her present areas of research are chemical contamination of coastal, estuarine and port waters; characterization and management of dredged material; Sediment Quality Assessment: bioassays, passive samplers; environmental impact: marine monitoring programmes. She has participated in interdisciplinary collaborative projects at national and international level. She has leaded numerous national and regional projects and she has gained experience in research cruises. She recently has participated in European transnational projects in relation with chemical contamination of priority substances in marine waters: MONICOAST (Jerico Next Programe) and MONITOOL (Interreg Atlantic 2016-2020); and in relation with the management of dredged material: PORTONOVO (Interreg Atlantic 2007-2013). Since 2001 participates in the ICES group of experts for marine sediment contamination. In various occasions she has been granted by scholarships to work abroad, in Poland, Scotland and Australia. MJ Belzunce is author/co-author of 55 peer-reviewed scientific papers, 7 book chapters and more than 80 technical-scientific/research consultancy reports. She has participated in more than 50 International Conferences with oral presentations.

Sonja Faetsch, PhD at Hamburg University of Applied Sciences HAW (DE)

My name is Sonja Faetsch and I am a PhD student in the Sullied Sediments Project since 2017. I am part of the workgroup Applied Aquatic Toxicology of Susanne Heise at the University of Applied Sciences Hamburg. I have a Bachelor of Science in Biology from the University of Cologne and a obtained a Master of Science in Marine Environmental Science from the University of Oldenburg. I am a dedicated to environmental protection and sustainability and therefore chose to specialise in ecotoxicology. My main research interests are studying the biological effects of complex pollutant mixtures in the environment and the molecular modes of actions of chemicals as well as science based-based decision making in environmental management. The subject of my PhD thesis is to improve integrated sediment quality assessment to develop better guidelines for the management of dredged material. One of the main aspects is to identify an optimized combination of bioassays in ecotoxicological test batteries.

Ute Feiler, Federal Institute of Hydrology BfG (DE)

Ute is a biologist by education with a PhD in the field of photosynthesis. She moved to sediment ecotoxicology in 1997, when she joined the German Federal Institute of Hydrology (BfG) where Ute is now heading the laboratory of ecotoxicology. Her focus is on the assessment of sediments in German water ways. Ute developed, validated and standardized methods for sediment assessment (e.g. the sediment contact test with *Myriophyllum aquaticum* (ISO 16191). She coordinated the joint research project “SeKT - Definition of reference conditions, control sediments and toxicity threshold for

freshwater sediment contact tests" (2005-2009), and is currently involved in the German EU Life integrated project "LiLa – Living Lahn" (Life14-IPE-DE-022), where she is leading the action "development of a sediment management concept for the river Lahn".

Jan Hendriks, Radboud University Nijmegen (NL)

Jan is an ecotoxicologist by education and specialised in fate, accumulation and effect modelling of substances in water and sediment of temperate and polar regions. For over 30 years, he has been involved in projects funded by governmental bodies (e.g., International Rhine Commission, EU/DG Environment) and by industry. At Radboud he coordinates several programmes and courses in environmental science, ecology and water management (with Uni Duisburg-Essen). Current topics focus on assessment tools, cumulative stressors, ecosystems services, biodegradation and emerging compounds.

Sebastian Höss, Ecossa (DE)

Sebastian Höss is an ecologist and limnologist by training and works since over 25 years in the field of sediment ecotoxicology. 20 years ago, he funded a small research and contract laboratory (Ecossa) focusing on the use of meiofauna, i.e. nematodes, for the assessment of water, sediment and soil quality. He developed, validated and standardized tools for effect-based sediment assessment, including a sediment toxicity test with the nematode *Caenorhabditis elegans* (ISO 10872), a bioindicator system to evaluate the ecological status based on in-situ freshwater nematode communities (NemaSPEAR[%] index), and small-scale microcosms for a higher-tier risk assessment of chemicals. Sebastian is interested in implementing effect-based tools for sediment quality assessment in water management frameworks and cooperates with universities and end-users in national and international projects. Sebastian is interested in the use of sediment toxicity testing along with sediment chemical analysis to unravel cause-effect relationships between the chemical and ecological status in aquatic ecosystems (especially sediments).

Maja Karrasch & Annette Kramer, Hamburg Port Authority (DE)

We work as biologists in the environmental monitoring unit of the Hamburg Port Authority in Germany. Our responsibility is the assessment of sediments in the Hamburg part of the river Elbe and the monitoring of effects caused by the deposition and relocation of dredged material. Within our monitoring activities we consider chemical-physical and ecotoxicological data on sediments and bioaccumulation data in biota of the marine realm.

Aourell Mauffret, National Institute for Ocean Science IFREMER (FR)

Aourell Mauffret is a researcher working on the transfer and effects of chemical contaminants in marine ecosystems. She is particularly interested in the modulations of these processes in regards to the various combinations of environmental pressures. She is involved in MSFD descriptor 8, as scientific responsible in charge of good environmental status definition and assessment in order to ensure that contaminant concentrations in the environment does not cause adverse effects to marine organisms. More specifically, she is actively involved in 1) the monitoring design of fish contamination and biological effects monitoring and 2) the development of indicators linked to contaminants in sediment and in biota, as well as indicators linked to chemical/biological integrated assessment. One of my research question is "how to bring monitoring data useful for environmental assessment?".

Iratxe Menchaca, Marine and Coastal Environmental Management AZTI (ES)

PhD in Marine Biology from the University of the Basque Country (Spain), focused on ecotoxicology as a tool for the marine and estuarine sediment integrative assessment. She has conducted interdisciplinary research in the field of management and assessment of marine environment for nearly ten years. She has worked in the implementation of some European Directives (i.e. Water

Framework Directive and Marine Strategy Directive). She has participated on the following selected European/framework contracts: EMODnet (Human Activities), MEDCIS/MEDREG (Assessment of the marine environment health status in the Mediterranean), MONITOOL (Assessment of chemical status of transitional and coastal waters, allowing the use of passive sampling devices), WESE/RICORE (Environmental monitoring around wave energy converters operating at sea).

Ginevra Moltedo, Italian Institute for Environmental Protection and Research ISPRA (IT)

Ginevra Moltedo is a biologist of ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale), specialized on marine ecotoxicology with strong focus on biomarker analyses (at molecular, cellular and histological level) in marine organisms. She is responsible of the Biomarker Analyses Laboratory, aimed to measure the health status of some target species related to water column or sediment, such as clams, mussels, fishes and polychaetes (besides some terrestrial species). In the last 15 years she has successfully led numerous projects on marine environmental monitoring of potential effects of offshore anthropic structures and related activities, including accidental or regulatory discharges (i.e. platforms for hydrocarbon extraction, terminals for regasifying liquefied natural gas, underwater pipelines, shipwreck). She currently gives her support to the Italian Ministry for the Environment and the Protection of Land and Sea elaborating Guidelines and technical opinions for the EIA Commission. She was member of the Online Expert Group on Contaminants for UNEP/MAP-MEDPOL and, at the moment, she is involved in the definition of the Italian strategy (methods and criteria) aimed to assess the contaminant effects in the National Environmental Monitoring Programme according to the Framework Directive on the Marine Strategy (2008/56/EC).

Lorenzo Morroni, Italian Institute for Environmental Protection and Research ISPRA (IT)

Lorenzo Morroni got his graduation in Marine Biology at Pisa University in 2011. In 2016 he obtained his PhD degree on the applicative perspectives of ecotoxicological assessment criteria in harbor areas, with particular attention to the toxicological effects of metals on sea urchin embryo development. He currently holds a position of researcher (fixed-term) in ISPRA. Current topics in his basic research are marine ecotoxicology of trace metals on embryo development of echinoderms. His applied research focuses on the application of ecotoxicological bioassay in the valuation of the environmental quality of dredging sediments, developing new protocols of embryo bioassays in situ and under laboratory conditions.

Cristian Mugnai, Italian Institute for Environmental Protection and Research ISPRA (IT)

Research technologist at Italian Institute for Environmental Protection and Research ISPRA based in Rome (IT) since 2011. He previously worked at Institute of Marine Science, National Research Council (ISMAR-CNR) based in Bologna as a temporary researcher and visited the Department of Geography, University of Toronto, Canada as a post-doctoral fellow. His 20-year expertise is based on the study of the impact of human activities on the marine environment. His main field of interest is the integrated chemical-ecotoxicological characterization of coastal and harbor sediments addressed to their management. He provides support to the Italian Ministry of Environment on environmental issues of harbor dredging and on the drafting of technical regulation on sediment handling. He has been involved since 2003 as advisor of the Italian delegation to the London Convention and London Protocol 1996 consultative meetings and scientific group meetings (IMO), as well as expert at MED-POL meetings in the framework of UNEP-MAP.

Anna Osypchuk, International Council for the Exploration of the Sea, ICES (DK)

MSci in the Aquatic Env. Biology, specialized in ecotoxicology. Anna works at ICES as Data Manager for (Marine) Environmental data and supporting systems and projects, including data types like contaminants, litter, biological communities.

The questions of interest for me during the workshop are: Indicators for contaminants and effects in sediment towards future assessments; data requirements and limitations; important co-factors for the assessments; data mining.

Daniela M. Pampanin, University of Stavanger (NO)

Daniela M. Pampanin has been leading environmental monitoring programs for multiple contaminants in different countries with a specific focus on PAH compounds. Her research has applied proteomic analyses, using mass spectrometry, and biochemistry methods to better understand the sub-lethal effects of contaminants on marine organisms. Through collaboration she has also been involved in research exploring the isolation and identification of natural bioactive peptides from fish as well as bioprospecting, adding value to fishery industry waste. She is a member of the Working Group on Biological Effects of Contaminants (WGBEC) of ICES and previously on the board of the Norwegian Proteomics Society.

Joana Raimundo, Portuguese Institute of Sea and Atmosphere IPMA (PT)

I'm a Pos-Doc researcher at the Portuguese Institute of Sea and Atmosphere (IPMA) - Division of Oceanography and Marine Environment and a member of the CIIMAR team included in the Global Changes and Ecosystems Services. I graduated in Marine Biology (2000), have a MSc in Marine Sciences (2003) and a PhD in Biochemistry (2010). My main research area is focused in the relations between exposure, fate and effects of contaminants in marine organisms, searching for responses and effects through biochemical or cellular modifications. Expert for IPMA in the ICES working group of biological effects of contaminants (WGBEC) and coordinator of the Descriptor 9 in the MSFD.

Elena Romano, Italian Institute for Environmental Protection and Research ISPRA (IT)

My name is Elena Romano and I’m working as researcher at ISPRA, formerly ICRAM, since 1998 which give scientific support to Italian Ministry of Environment. I’m marine geologist and my research activity is mainly devoted to understand the environmental stress induced by human impact on the coastal zone by studying the sedimentological and geochemical characteristic of marine sediments, from transitional and coastal environments, connected to the contamination levels. Most of my studies are related on sampling strategies and analytical methods for marine sediments and the geochemical and environmental characterisation finalised to the reclamation of coastal marine areas near dismissed industrial sites; but also on coastal monitoring during the mobilization of sediment (i.e. dredging). In addition, I’m studying the response of environmental indicators (benthic foraminifera) to anthropogenic environmental stress, in addition to chemical-physical environmental characterisation. I’m author and/or co-author of several scientific articles on international journals. I have been co-tutor of PhD thesis and Editor for special volume on Marine Pollution Bulletin and Journal of Soils and Sediments.

Jeanette Marie Rotchell, University of Hull (UK)

My research is in the area of Environmental Toxicology. Current projects include cancer in fish, endocrine disruption and photoperiod in bivalves, inland waterways sediment characterisation of EU Watch List chemicals, microplastics in seafood supply chain, and pharmaceuticals in the Humber Estuary. The main recent research accomplishments are: consistent publication track record in international journals, EU grants including the recently funded (~€4 million) project Sullied Sediments: http://northsearegion.eu/sullied-sediments/, a steady stream of PhD students completed, and Visiting Professorships at the University of Hawai’i and the State Key Lab for Coastal & Estuarine Research, Shanghai, China. My work is applied, impactful at an EU level, with a strong track record in interdisciplinary collaborative working, as all as being stakeholder/end-user driven. I am lead for a research cluster on Human Health & Emerging Environmental Contaminants.

Sabine Schäfer, Federal Institute of Hydrology BfG (DE)

I studied biology in Düsseldorf and Bremen and did my PhD in marine toxicology at the Alfred Wegener Institute for Polar and Marine Research. Since 2010 I work as a scientist in the department „Ecotoxicology/Biochemistry“ at the German Federal Institute of Hydrology in Koblenz. In my work, I focus on bioaccumulation, passive samplers and sediment quality. Presently, I am particularly interested in applying passive samplers for monitoring dredging activities or sediment disposals. For this (and other) purposes, we have established a set a passive samplers for organic chemicals in our team and gained substantial experience in their practical application during the last years. We also conduct bioaccumulation studies either in combination with monitoring activities (e.g. transposition experiments during dredging operations) or as lab studies. I am further interested in improving aquatic bioassays e.g. by implementing passive dosing as a novel dosing technique for hydrophobic organic chemicals.

Ingrid Tjensvoll, Swedish Environmental Protection Agency (SE)

Ingrid is a marine ecotoxicologist and did her PhD on suspension of polluted sediments. Since her PhD Ingrid has worked as a consultant for several years where she mainly worked with polluted sediments in different kind of projects. As a consultant she performed many sediment sampling projects connected to different construction project, risk assessments of sediment, environmental impact assessments of different human activities and sediment monitoring projects. Currently she is working on the Swedish EPA on a project focusing on polluted sediment. The main aim of this project is to increase the knowledge about polluted sediment in Sweden. One of the work packages in this project is to develop new guidance regarding risk assessments of polluted sediment.

Barbara Träxler, Geological Survey of Austria (AT)

My name is Barbara Träxler. I am employed at the Geological Survey of Austria in the department of mineral resources. Most of the projects I can work on are related to sediment petrography. Due to my participation and experience in the sampling of stream and floodplain sediments for the Geochemical Atlas of Europe (FOREGS) I am currently also working with other colleagues of the Geological Survey for the SIMONA project, an Interreg Project in the Danube Transnational Programme. SIMONA stands for Sediment-quality Information, Monitoring and Assessment System to support transnational cooperation for joint Danube Basin water management. The main objective of SIMONA is to respond to the current demand for effective and comparable measurements and assessments of sediment quality in surface waters in the DRB by delivering a ready-to-deploy Sediment-quality Information, Monitoring and Assessment System to support transnational cooperation for joint DRB water management.

Joanna Uzyczak, CEFAS (UK)

Joanna Uzyczak is an experienced biologist, trained to M.Sc. level, with a strong background in Environmental Biology, Analytical Chemistry and Ecotoxicology. She has an extensive experience of working in laboratories, fieldwork and at sea. She has been working at CEFAS for the past twelve years. For the first six years, she was part of the Organohalogens and Nutrients team working as an Analytical Chemist. During this time, she gained substantial experience in analysing sediment samples for various pollutants also under Dredged Material Disposal Site Monitoring Programme. Joanna moved to Ecotoxicology team (ECORA) in 2015 and currently conducts research work and GLP accredited studies at the Cefas Lowestoft Laboratory. Joanna has been involved in many projects over the past years, delivering research programmes for commercial and government customers. In 2016 she was involved in dredge sediment toxicity assessments carried out at Cefas.

Katrien Van de Wiele, OVAM (BE)

Katrien Van de Wiele works for the Public Waste Agency of Flanders, OVAM and has extensive experience working in projects on soil and groundwater remediation. Since 2012 she is policy coordinator and team leader for the (contaminated) sediments area at OVAM.

Helen Walton, CEFAS (UK)

Helen Walton is an aquatic ecotoxicologist with a background in both freshwater and marine ecotoxicology. Whilst Helen's main work encompasses the use of Good Laboratory Practice compliant standardized testing in a regulatory context, she is also experienced in the development of non-standard tests to meet specific customer and regulator needs. Over the past 10 years she has been involved in a breadth of research from bespoke freshwater mesocosms to chronic marine bioassays. Although fairly new to the world of dredge sediment Helen was the project manager for dredge sediment toxicity assessment carried out at Cefas back in 2016 and she has a keen interest in refining test methodologies to ensure read across.

Ann-Sofie Wernersson, Swedish Geotechnical Institute (SE)

I am an aquatic ecotoxicologist working at the Swedish Geotechnical Institute since Nov 2018. I coordinate the development of a national guidance on sediment risk assessment, including assessment criteria, to be used in a remediation context. I also work part time in different research projects, and provide expert advice to Counties, on sediment related topics in specific projects. Between 2012-2018 I worked at the Swedish Agency for Marine and Water Management, on WFD related topics, such as guidance and legislative texts on status classification of priority substances. I also developed sediment EQSs that were adopted in national legislation. Involved in the development of a guidance on dredged material assessment. Participated in negotiations connected to environmental Court cases of national priority. Swedish HOD in CIS Chemicals and chaired a drafting group on effect based monitoring methods. Previous positions: County Administrative Board, FB engineering (consultant), Swedish Chemical Agency and Göteborg University (lecturer in applied environmental science). I did my PhD on risk assessment of PAH phototoxicity (2002).

RESEARCH QUESTIONS – Background and Results of the Discussions

Topic A: Application of ecotoxicological testing in sediment quality and dredged material assessment frameworks

Background

Ecotoxicologists have argued for a long time, that the use of ecotoxicological information in sediment and dredged material management would result in environmentally safer decisions. However, the implementation of biological effect-based assessment in European regulation is low (Fig. 1, from Heise et al. (2020)).

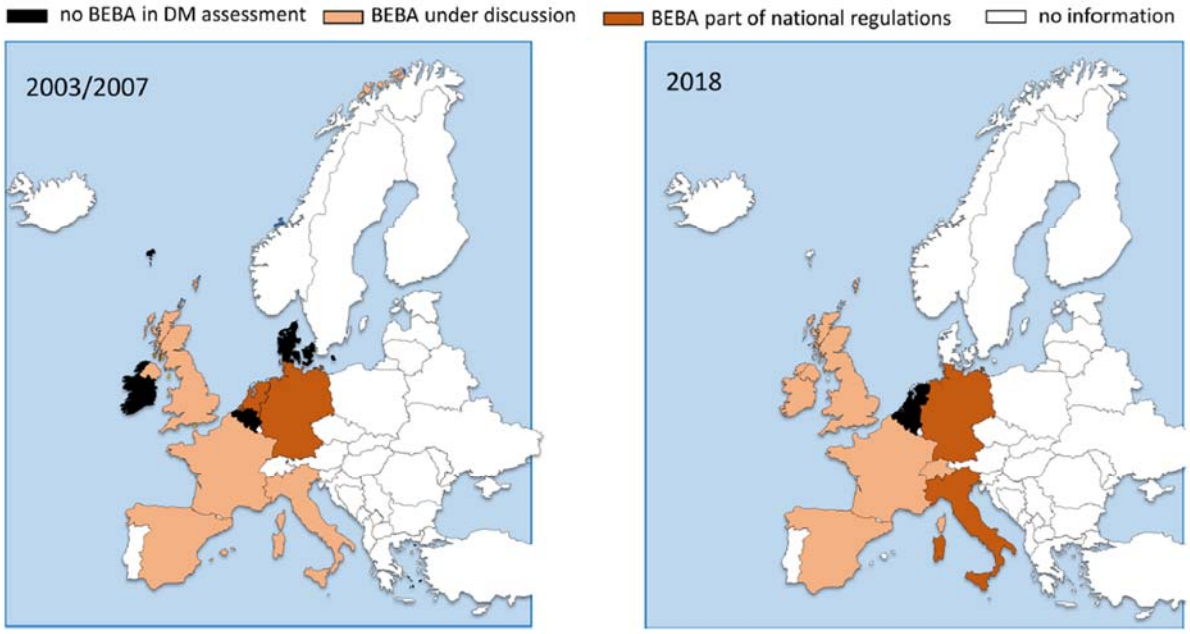

Fig. 1 Status of the inclusion of biological effect-based assessments (BEBA) into national regulatory frameworks for dredged material (DM) in European states in 2003/2007 compared to 2018 (based on den Besten et al. 2003; den Besten 2007 and the outcome of the SedNet & Sullied Sediments Workshop 2018)

The reluctance of decision makers and regulatory bodies to include ecotoxicological data in decision-making frameworks has a number of reasons. These are reflected by the challenges and research questions which the participants identified prior to the workshop:

Diversity of biotest batteries in use

There are a lot of different biotest batteries that researchers use and suggest for application in Europe. Stakeholders claim rightfully, that the outcome of biotest batteries may depend very much on the type of organisms that are used. So, of this variety of bioassay combinations, which ones are the best and should be used? Could we as scientists agree on a specific battery? Would it be helpful if we did? Is there something like “the best” biotest battery for all cases or should it be adapted to the respective management objective? Can we develop a “universal” system to integrate sediment toxicity into sediment quality classification? and Are there perhaps other possibilities to harmonize a biological effect-based assessment than agreeing on only one combination of bioassays?

Uncertainty / reliability of biotests

Another challenge that stakeholders are concerned about is the reliability of ecotoxicological data. This refers to reproducibility of biotest results and how these may be influenced by confounding factors, for instance. But this topic also addresses the way that ecotoxicological data, which have a certain intrinsic variability, can be integrated into decision making. From the stakeholders point of view, it is extremely important, not to have any false positive results which would lead to costly management decisions without need. Neither should there be false negative results (e.g. due to lack of sensitivity towards emerging substances), which may cause environmental damage due to overlooked stressors.

Can significance of ecological test results be improved by taking measurement uncertainties into account? Can the integration of a screening biotest into an early tier reduce the frequency of "false" results? In an assessment scheme that follows the sediment quality triad, where ecotoxicological, chemical and ecological data are considered equally, how do we define "false negative" or "false positive" results, anyway? And can we develop a robust tool that integrates the responses of various biotests, chemical and ecological data for decision making?

Ecological relevance

The ecological relevance of ecotoxicological tests is considered another important challenge. The question was raised, whether ecotoxicity data could form a bridge between the ecological status and the chemical status as defined in the Water Framework Directive (EU-WFD). Currently, the chemical status which is assessed on the basis of water quality criteria (WQC)-exceedance, and the ecological status which is mainly based on benthic community data are regarded separately. It may be interesting to discuss, whether these two criteria could be linked via studying the responses of organisms to chemical stressors in the laboratory.

Most biotic indices are based on macrofaunal analyses. These take time and are expensive. Additionally, macrozoobenthos only reacts to moderate chemical stress with a certain time lag. And with the analysis of marine communities, we only detect the ecological damage when it is already occurring. We should aim to provide tools to prevent damage at higher ecological level. Consequently, broadening the approach to other diversity or activity indices which are less time consuming, less costly, more protective and which react faster and more specific to chemical stressors may be worth investigating. How to integrate community analysis data (of macro-, meio- or microbenthos) into classification approaches for sediment quality assessment, however, needs to be studied (e.g. relevance of indices).

Even more challenging is the establishment of ecological relevance when it comes to *in vitro* biotests or use of molecular endpoints (e.g. biomarker genes expression level). Tests for genotoxicity or endocrine activity, for example, may characterize a sediment. In the light of missing relevant exposure pathways, an interpretation with regard to actual effects on the aquatic community remains difficult.

Looking at molecular endpoints may however give crucial information on the key events leading to adverse biological effects observed at higher level of biological organization. How to integrate and interpret –omics data (e.g. transcriptomics or proteomics) in the biological assessment of sediment is a future challenge, as interest for those approaches in environmental risk assessment is growing.

ALL THESE QUESTIONS AND CHALLENGES…

…can only be addressed in direct exchange between and among those stakeholders which have to manage sediments and dredged material, and those scientists and technicians that develop and apply bioassays to sediments, interpret ecotoxicological data and establish assessment schemes for data interpretation.

The objective of this workshop was to bring together a mixed group of people representing academia, business and administration/regulation in order to tackle these questions and move ahead on these topics.

Results of the discussions

EXCHANGE OF EXPERIENCE REGARDING THE CHALLENGES OF ECOTOXICOLOGICAL TESTING/DATA AS A TOOL IN DECISION MAKING/ASSESSMENT FRAMEWORK.

During this first day, participants were encouraged to share their experiences during two differently composed "break out" discussions groups. Impulse presentations on the topic were shown by Sabine Apitz, SEA Environmental decisions, giving an overview over ecotoxicological implementation in European regulation, and by Anette Kramer and Maja Karrasch on the challenges that the Hamburg Port Authority faces having to base part of their decisions on the fate of dredged material on ecotoxicological data.

The results of these breakout groups are summarized below:

Uncertainties/Reliabilities when testing natural sediments:

- As all standardized biotests have to go through round-robin testing, so it has been made sure that their results are in the statistically allowed variation of reproducibility. These round-robin tests, however, are usually carried out with artificial sediments that have been spiked with test substances. When testing natural sediments, ecotoxicity data seem to differ quite a bit between laboratories when they performed bioassays on the same sediments (as was shown by the impulse Annette Kramer & Maja Karrasch, HPA). Biotest results also showed high spatial (in otherwise homogeneous areas) and temporal variabilities.
- The challenge thus is that hardly (if any) interlaboratory comparisons of ecotoxicity testing are performed on natural sediments!
- A big problem that can lead to different outcomes with the same test system but in different labs may be the preparation of the samples (including storage conditions, storage time, sieving, no sieving, aeration, centrifugation of elutriates etc.).
- There is little knowledge on the impact of matrix effects on the different biotest organisms.
- The impact of confounding factors (such as sulfide, ammonium etc.) is difficult to quantify for the various test systems.
- There are also few systematic studies on reproducibility/reliability of ecotoxicological data on natural sediments that derive from intralaboratory comparisons.

Ecological relevance:

- There are few studies that compare how results from biotesting sediments relate to the biological community. Should the data of bioassays be seen as a sediment property/hazard or should we expect an ecological relevance? How do we explain in this regard a case, when sediment that has a very poor biological diversity but shows low toxicity in the laboratory (when no environmental factors plausibly caused a deterioration)? The statement, that other environmental factors had to be involved, could be more easily communicated if there were

good examples of such cases, identifying the environmental causes. In this case is very relevant to communicate adequately with stakeholders, including maybe the explanation of concepts such as 'bioavailability' of pollutants.

Biotests for decision making:

- When interpreting biotest data, test results need to be categorized into "not toxic", "moderately toxic" or "highly toxic", for example. The number of categories that are possible depends on the variability of the bioassay: a highly variable test system can probably only be used to differentiate: "not toxic" and "toxic" samples. However, already this differentiation is difficult, as we hardly have any uncontaminated natural sediment to test. Thus it is a challenge how to determine toxicity thresholds, if there is no "blind", and how to make sure that toxicity above the threshold is a signal.
- In some regulations, a biotest battery is assessed with regard to the „one out – all out" principle (the worst result influences the decision). Cannot we come up with a more integrated assessment, supplementing the chemical (and ecological) information?

A WAY FORWARD ...

In the second part of DAY 1 (world café) and on DAY 2 (longer discussions in groups), a way forward was discussed, focusing on a limited number of questions that had in particular emerged from the previous discussions.

How can we improve the reproducibility of ecotoxicological data?

- We need to identify which of the different steps from sediment sampling to measuring responses are most critical with regard to the outcome (i.e. which factors have what influence on the measured results). For instance, these steps comprise:
    - Sampling
    - Preparation of sampled material (extracts, etc.)
    - Cultivation of test organisms or maintenance of field collected organisms
    - Laboratory material (storage, quality, cleaning protocols)
    - Test procedure
    - Time line
    - …

  A guidance should then be developed, specifically drawing attention to the critical steps, and this could then be used to elaborate common precise protocols.
- Interlaboratory/intercomparison exercises should be carried out with the same sediments, organisms, procedures. Operating procedures and protocols need to state every detail, because for example, there is evidence, that the time between sampling and testing is more crucial than expected (see above) (impulse presentation by Susanne Heise).

How can we improve the reliability of ecotoxicological tests in decision making?

- The toxicity categories (e.g. not-toxic, slightly toxic, moderately toxic, highly toxic) must be adapted to the resolution of the test system (both from a statistical and experimental point of view).
- For decision making, the protection goal needs to be clarified (Benthic organisms, Protection against secondary poisoning).
- The frequency and intensity of monitoring in the field should increase, in order to get a better data set and identify seasonal, spatial and interannual variabilities.
- Potential institutions, that could support these activities (”umbrella”) would be BEQUALM, ICES, Quasimeme, …

How to be sure that results above a specific threshold value correspond to a real signal (toxicity)?

- The procedures have to be very well standardised (reliability, replicability, reproducibility) and precise protocols should be defined.
- Adequate controls have to be used (significant deviation in the samples from the controls).
- The test specific statistical variability of results should be known/communicated.
- Information should be compiled on the sensitivity of biotests with regard to confounding factors[2].
- Outliers could otherwise present a problem. How likely are they?
- We need studies that identify for the respective test systems, what a ”real signal” is. Currently a cooperation effort is on the way involving BfG, the Ecotox Centre, ECOSSA, the Italian Water Research Institute and the Hamburg University of Applied Sciences.

THE NEXT STEPS …

Can we develop better approaches to integrate data from different biotests (within a battery) into one indicator of sediment quality?

We should not re-invent the wheel, but adapt/optimize/build on current approaches. Especially in the US and Australia, various methods have been developed and applied. For an overview/summary see

Wenning et al. (2005) (free SETAC publication
https://www.setac.org/store/ViewProduct.aspx?id=1038039

or

[2] Some information on that matter, especially for marine bioassays, have been compiled in the following ICES documents:
https://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR315.pdf
http://ices.dk/sites/pub/Publication%20Reports/Techniques%20in%20Marine%20Environmental%20Sciences%20(TIMES)/TIMES51.pdf

Simpson and Batley (2016) (free download from https://www.researchgate.net/publication/287218086_Sediment_Quality_Assessment_A_Practical_guide).

But there are also several approaches in Europe, in which the outcome of biotest batteries is considered as one line of evidence, integrating data from different biotest assays (see Italy's approach in regulatory frameworks (→ contact Cristian Mugnai), or the fuzzy logic expert system approach within the sullied sediments project – stay tuned (→ contact Susanne Heise).

To do: Cooperative effort in which we compile what approaches there are in Europe and take into account the US-expertise. We will run the same data by the various assessment schemes and compare the outcomes, analyze differences, give an overview over pros and cons (Volunteers to join such an effort: Christian Mugnai, Rebecca Beauvais, Susanne Heise, Sabine Apitz, Juan Bellas).

What can we do in order to improve the reliability of ecotoxicological data? What biotests are we talking about?

We need to gain information on uncertainties, e.g. confounding factors, storage conditions, etc. by conducting specific studies. It became clear during the discussions, that quite a few studies are or have been performed at different institutions, but the outcomes are not shared. A forum for exchange our knowledge in this regard should be established, so that we learn what are the most crucial steps in performing the biotests (e.g. time until elutriates are tested, centrifugation, elutriate preparation (water/sediment volume, filtration…). The same applies to confounding factors: What are the impacts of NH_4 on different organisms? What are the sensitivities towards sulfides or matrix effects on the different biotests? Instead of collecting bits and pieces individually, we should work together collaboratively to get a better picture.

To do: Carmen Casado and Susanne Heise coordinate the SedNet workgroup on sediment quality. We will propose a special session on the next SedNet conference tackling exactly this question. That session will not consist of different platform presentations but will provide space and time to exchange results of small or large studies that provide information on this topic. (Update: This special session has been proposed, we are awaiting responses).

What else can we do to support the use of biotest in decision making?

Mistrust of stakeholders towards ecotoxicity data is high. The main reason for that are high interlaboratory deviations (see discussion above). Other ones address observed phenomena such as toxicity depending on e.g. seasonality which is not addressed in assessment schemes and remains unexplained, and spatial variability in otherwise apparently homogenous areas. More scientific underpinnings of such observations would help stakeholders to gain confidence. However, it needs to become clear that the effect from chemical cocktails has to be seen as a part of a complex system that is influenced by the sediment matrix, history of the contamination, composition of chemical mixture, the environmental factors, etc. As long as we do not clearly understand the geochemical and biological processes, we may not be able to understand exactly, why effects occur.

To do: Methods that may help studying the effects of e.g. seasonality (or of other parameters, which do not seem plausible at first glance) could be:

- Bioaccumulation in benthic organisms (integrating effects over a longer time).
- Meiobenthos community diversity (NemaSPear Index).
- Passive sampling (integrating effects over a longer time).
- Effect directed analysis (EDA) to identify sources/causes for toxic responses.

In addition: Examples and case studies would be helpful to strengthen confidence of stakeholders in bioassay results. Please exchange these via e.g. the SedNet workgroup on sediment quality (→ contact Carmen Casado or Susanne Heise).

How can we assess the ecological relevance of *in vivo* and *in vitro* tests, and of biotest battery results / sediment quality classes, respectively?

„Ecological relevance“ should be defined in the context of the respective management objective (e.g. *in situ* sediment quality versus dredged material disposal). While the ecotoxicological data should have an environmental significance, it should not be expected that results from laboratory tests that include the manipulation of environmental samples can be directly extrapolated or transferred to the status of the biological community. Searching for a correlation of ecotoxicity data with community data is misleading. Sediment toxicity is one line of evidence that describes a sediment property and should not be seen as reflecting the quality of the biological community.

To do: To inform on the environmental significance of ecotoxicological test systems, sensitivities of test organisms could be compared for instance with the sensitivity of the targeted sediment organisms (e.g. Frühling et al. 2001; Haegerbaeumer et al. 2018).

References

Frühling W, Rönnpagel K, Ahlf W (2001) Effect of zinc and benzalkonium chloride on Nitrosomonas communis and potential nitrification in soil. Environmental Toxicology 16:439-443

Haegerbaeumer A, Höss S, Heininger P et al. (2018) Is Caenorhabditis elegans representative of freshwater nematode species in toxicity testing? Environmental Science and Pollution Research 25:2879-2888

Heise S, Babut M, Casado C et al. (2020) Ecotoxicological testing of sediments and dredged material: an overlooked opportunity? Journal of Soils and Sediments. 20:4218–4228. https://doi.org/10.1007/s11368-020-02798-7

Simpson S, Batley G (2016) Sediment quality assessment: a practical guide. Csiro Publishing,

Wenning R, Batley G, Cg I et al. (2005) Use of Sediment Quality Guidelines & Related Tools for the Assessment of Contaminated Sediments. Society of Environmental Toxicology and Chemistry (SETAC), Pensacola (FL)

Topic B – Sediment quality criteria and their efficiency to protect the environment and its living resources.

Background

Sediment Quality criteria linked to ecotoxicology

There are different ways to derive sediment quality criteria using ecotoxicological methods, some directly, some using partition coefficients and others using combined ecotox and chemical information together. All have advantages and disadvantages. Which do we think are the most reliable to take forward as part of a decision-making framework and why? What further work needs to happen to provide the confidence required by stakeholders involved?

This should include consideration of

- The different chemical analytical methods relationships and how they link to bioavailability of contaminants.
- Use of total organic carbon in assessments.
- Emerging contaminants.
- Regional differences.
- Evaluation of efficiency.

Results of the Discussions

REFLECT ON SEDIMENT QUALITY CRITERIA AND THEIR EFFICIENCY TO PROTECT THE ENVIRONMENT AND ITS LIVING RESOURCES

Day 1 Summary points:

- When comparing with chemical analysis either have to check method is appropriate (partial digest for metals, for example) or be able to remove confounding factors if want to make sure relevant to bioavailability.
- If using cofactors such as organic carbon (black carbon) make sure relationship exists before applying.
- Check how pollution is defined within the regulations being worked to first to determine which tests will be most relevant.
- More data needed for benthic organisms in relation to bioassays.
- Also greater awareness of emerging contaminants going forward and how these relate to ecotox testing.
- General agreement that combined thresholds (chemically and ecotox derived) work well but may be overprotective.
- Regional differences need consideration
- Measuring efficiency/ effectiveness of threshold chosen is one of the biggest challenges.

How can we be sure that our threshold values are a real signal?

THE NEXT STEPS ...

Context important

The threshold used should link to the activity/impact being assessed.

What type of effects are you concerned about

The threshold used may vary depending on whether you are concerned about bioaccumulation or secondary poisoning.

Bioecological community effects may be linked more to physical disturbance rather than increasing contaminant.

Some changes can introduce positive effects.

For disposal site monitoring, comparison of reference site to disposal site completed to determine offset caused by disposal activity. Use this direct comparison rather than assessments using thresholds.

Having upper and lower range rather than one threshold limit and thresholds that are effects-based

Sweden does not use thresholds for dredging/disposal of sediments. EQSs which are derived on effects-based methods. If these were used as thresholds, then it is likely no disposal would be possible. Guidance for disposal of sediments requires consideration of comparable sediment concentrations with the concentrations in the area where it is planned to dispose the sediment. Similar to provision of regional thresholds, as well as weight of evidence approach. Case by case basis assessed. While no effects-based thresholds used, effects based monitoring has been completed since the 1980's, including fish (4 stations) and imposex assessments around the coast, except in the north where there are brackish waters.

Recommend a range of threshold values is better than one threshold value. If possible, could there be more EQS thresholds (an upper and lower) be provided rather than just one.

Where there are two threshold levels (or more) then the lower thresholds tend to be based on background concentrations and the upper thresholds tend to be based on biological effects research. Spain has set five thresholds, with the first three being derived using background concentration data. While it is understandable to use background concentrations for the lower concentrations as these are the concentrations that exist in the environment, generally the main reason for assessing dredge sediment is make sure no biological effects will be caused by disposal of sediment, so biological or chemical combined with biological effects thresholds preferred.

Awareness/understanding most thresholds are derived in laboratory with controlled conditions

Requires good general knowledge base about the sediment being disposed, and the nature of the disposal site.

Thresholds that are implemented are generally based on *ex situ*/laboratory experiments and not from measurements taken *in situ*, directly in the environment being assessed. ERLs/ERMs (Long et al, 1995) for example are produced in controlled conditions for both chemical and effects on benthic communities' measurements.

Laboratory experiments are important but how representative are they of the real environment.

Thresholds that are laboratory and environmentally derived (potentially using passive sampling, for example) are likely to be more realistic and provide better indicators.

Difficult to measure *in situ* at offshore sites. Methods need to be practical and therefore mostly have to be completed in laboratory setting. Even then can be difficult to collect biological (and less so sediment) samples and be able to get them to the laboratory for analysis.

Good to compare threshold methods on own regional datasets

The German River Basin Community (RPC) Elbe conducted a biomonitoring study in the German part of the River Elbe in 2016. Fish and mussels were sampled by a contract partner at a total of 17 sampling sites in the adjoining German Federal States and environmental contaminants were analysed in these biota samples by a common laboratory. In the inland waters, preferably bream (*Abramis brama*) and in the tidal part of the River Elbe flounder (*Platichthys flesus*) should be sampled. It was planned that in both types of waters, mussels of the genus *Dreissena* spp. should be collected. However, mussels were only found at 13 of 17 sampling sites and at the majority of sites *Corbicula fluminea* were found whereas *D. polymorpha* were sampled at four and *Mytilus edulis* at one sampling site. Since accumulation of chemicals varies in different species this impeded assessment of bioaccumulation in mussels along the River Elbe.

MSFD uses thresholds to assess good environmental status, but regionally use of same species is impossible.

Threshold values are useful to help determine the relative differences but should be used as a tool to help prioritize where there may be an issue which can then be investigated further. Then if there are regional differences for example these can be used to explain why thresholds may be exceeded, as well as providing biological effects-based evidence showing if thresholds exceeded whether this affects presence of biological communities, for example.

Many of the thresholds used, particularly combined thresholds using chemical and biological effects-based measurements are derived from large North American datasets (ERLs, ERMs) or Canadian (PEL, TEL). Confirmation these thresholds are applicable outside of North America and Canada is desirable.

Precautionary approach is advocated.

References

Long ER, MacDonald DD, Smith SL, Calder FD (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19: 81-97

Topic C – Deriving sediment quality guidelines against the background of the European Water Framework Directive

Background

Frame

According to the EU Guidance Document No: 27 (Technical Guidance For Deriving Environmental Quality Standards, EU GD), EQSs for sediments are required to protect benthic (sediment-dwelling) species. They allow the assessment of good status alongside standards for other compartments, and are particularly relevant for hydrophobic substances and metals. When sediment EQS are subject to high uncertainty, the EU GD No 27 recommends a tiered approach where EQS exceedance would trigger a more detailed assessment that accounts for bioavailability or uses biological data to inform further action. It is critical to define the role of EQSs/SQGs in WFD. Are these to trigger remedial action *in situ*? To rank sites? To control dredging or movement? The purpose will drive the framing. Does SQGs need to be river basin or catchment-focused, national or Europe-wide?

Derivation

The EU GD provides guidance for the derivation process of EQS for sediments to protect benthic (sediment-dwelling) species. Ecotoxicity data from experiments with benthic organisms are preferred, but there is a general lack of data (systematic studies). Data requirements for substance registration are not sufficient for EQS derivation. We know too little about differences in sensitivity among different invertebrates, while vertebrates (benthic fish, amphibians), primary producers and microorganisms are hardly considered. So how can this be achieved? How can we balance uncertainty and practicability?

Water column ecotoxicity data used in conjunction with equilibrium partitioning can be used to derive preliminary EQS for sediments when no reliable sediment toxicity data are available. Are these EQS suitable to trigger further investigations? Any experience with the implementation/validation of this type of EQS? Do we need to recalculate an EqP based value according to site specific conditions? Do we have the supportive data (e.g. Koc values for different salinities, pH, etc.) we need to do that?

Empirical field or mesocosm data such as co-occurrence of benthos and chemical contamination in the field (TEL/PEL, TEC/PEC, etc.) can be used to modify the quality standard derived from ecotoxicity data. While high effect concentrations may be suitable to identify upper levels above which effects are expected to happen, thresholds effect levels may be suitable for EQS sediment derivation as they should provide concentrations where biological effects are unlikely to occur. What about the risk of co-correlation between substances? How can you be sure that the effect is due to that contamination (parameter) and it is not due to different influences and the effect of a cocktail? What is the influence of other parameters? What type of field data can be used in EQS sediment derivation?

What about substances found in sediments and that are primarily of concern due to secondary poisoning? Can we establish trigger values for sediments to signal the risk of food web transfer?

Implementation

Are methods for taking into account bioavailability (e.g. total organic carbon normalization) appropriate in practice?

How effective and robust are these methods for assessing the concentrations and composition of pollution in an environment? Should the "chemical status assessment" be made based only on the results of EACs, SQG, EQS comparison or including the potential toxicity which provides more comprehensive conclusions?

What about uniformity in sampling methods, and analytical techniques? Absence of this cause a lack of intercomparability of results.

Results of the Discussions

Several questions that were identified for Topic C were addressed during the discussion within Topic B (see above). The following complementary points were discussed:

ON DERIVATION AND IMPLEMENTATION:

- If thresholds are used in regulation, it is necessary that they are based on sediment toxicity data.
- Thresholds based on EqP are preliminary by definition (CIS-WFD GD) and its validation is challenging because it is difficult to extrapolate from the lab to the field. While they may be used for classification purposes, their use for decision-making does not appear recommended. There is no information on the implementation of such values by the countries that have derived them. This information should be shared and made available to increase the evidence on its performance.
- Field data have been used for deriving EQSs and SQGs for metals and traditional sediment contaminants in different countries and regions (see background documents). There is still few field data for emerging contaminants.
- The models/approaches for deriving EQSs/SQGs for substances that are potentially bioaccumulated and biomagnified are still highly uncertain or not well defined, so that most often the derived values are set at the background concentration (e.g. Sweden), which would be rather an exposure assessment rather than risk assessment. Some experiences exist on the derivation of such type of values matching sediment-biota information (e.g. Italy for marine sediments), although linking fish-sediment data is still challenging (experience in France). A review has been completed for Environment Canada on the challenges for deriving thresholds based on BAFs (S. Apitz) that would help finding the way forward.
- When EQSs have been derived, the information on derivation is not publicly available making difficult the comparison and potential harmonization of values.

ON HARMONIZATION

- There are few EQS for sediments, where available they are mainly for marine sediments. Sweden is the only present country that derives EQS for sediments. There is a bilateral exchange between Sweden and Denmark for comparison/harmonization of EQS for sediments.
- EACs were derived during the period 2000-2010, but not much work has been performed in the decade 2010-2020.

- There is a general agreement that it is difficult to reach harmonization among WFD-MSFA-OSPAR thresholds.
    - Harmonization among countries makes sense for monitoring purposes, but may not be appropriate for decision-making.
    - Harmonization at the catchment scale is necessary, taking into consideration local background and upstream-downstream continuum.

THE NEXT STEPS ...

As a first objective, efforts should focus on making publicly available threshold values from the different countries, including the derivation report and implementation experience.

Topic D – Applicability of passive sampling methodology to derive thresholds suitable for assessment purposes

Frame

Passive sampling is a relatively new method that is now being used for monitoring contaminants, mainly in water. Defining advantages and disadvantages of passive sampling for monitoring. How do we see passive sampling being included in decision-making frameworks in the future?

This should include consideration of

- The relationship between passive sampling and bioavailability of contaminants.
- Range of chemicals that can be measured by passive sampling, including potential for emerging contaminants.
- Use of passive sampling *in situ* compared with *ex situ*.
- Evaluation of performance.
- How passive sampling results compare with existing sediment quality criteria.

shed a light on the applicability of passive sampling methodology to derive thresholds suitable for assessment purposes.

Results of the Discussions

Day 1 Summary points:

- Relatively new method, but it is clear application of this technique is widening (refer to presentations given during the workshop).
- Recent publications discuss link to bioavailability and also have started to compare with existing sediment quality criteria, mainly in waters only (any references supplied will be shared with participants).
- Passive samplers measure the dissolved concentration of chemicals either in the water phase or in sediment porewaters. This dissolved concentration is considered the bioavailable and toxicological relevant contaminant fraction. However, it has to be kept in mind that some organisms ingest particulates and, thereby, can actively take up contaminants associated with these particles.
- Proposed useful as a screening tool to identify hotspots for remediation, followed by use for monitoring following remediation.
- Wide range of contaminants can be measured whereby different PS membranes are needed.
- Emerging contaminants can be measured -e.g. by non-target screening or targeted approaches.

What are the next steps required to be able to use passive sampling in dredged assessment frameworks, particularly in relation to sediments?

THE NEXT STEPS ...

- Methods are available and can be used. More studies and scenarios required to widen further confidence in use of passive sampling. Highlighted use for monitoring prior, during and after dredging as well as at disposal sites, for example. Refer to presentation by Sabine Schäfer.

- Need to be competent with the respective passive sampling technique. For example, contamination controls are particularly important since detection limits are low that contamination of passive samplers or sampler extracts needs to be carefully avoided.

- Complementary rather than substitute for biomonitoring now at least. Silicone-based passive samplers are often used for monitoring of hydrophobic organic contaminants (HOCs). The underlying mechanisms of contaminant uptake by these absorption-based passive samplers are well understood – in contrast to adsorption-based samplers. Furthermore, sampling rates of target analytes can be determined in situ by the use of performance reference compounds. Therefore, (absorption-)based passive sampling of HOCs has the highest potential to be used as a substitute for biomonitoring.

- Mussel cages can be used in parallel to passive samplers as a direct biomonitor to supplement passive sampler measurements. Sourcing of mussels or equivalent filter feeders can be difficult. DGT are known to work well with metals and similar pattern to hydrophobic organic compounds in terms of predicting bioavailability. Also bioavailability of polar compounds in water is less comparable with passive sampling concentrations. This may be due to active absorption into biota. SEDRIPORT project demonstrates that passive sampling concentrations do not correlate with biological effects measured directly (http://interreg-maritime.eu/web/se.d.ri.port). Passive samplers are different matrices (inert compared with cell membrane).

- Range of contaminants available for measurement needs expanding to include for example, TBT. Also needs to be considered for emerging contaminants and noted that rare earth elements already can be measured using DGT.

- Partition co-efficients for selected emerging contaminants will also need to be determined as long as contaminant concentrations in water or sediment porewater are required. Alternatively, concentrations in passive sampler can be indicated (e.g. ng/g sampler material or ng/sampler).

- How does depth/pressure affect calculations – need to understand this for use of passive samplers at depth for monitoring dredging activities close to seabed for example. Salinity and temperature can affect uptake of passive sampler. In the MoniTOOL project, salinity did not affect metals uptake but for organics was more of an issue. For silicone-based passive sampling of HOCs, contaminant concentrations determined by passive samplers can be temperature- and salinity corrected (Witt et al. 2020).

- Passive sampling of HOCs in sediment can be applied in situ. Indeed, this might be more difficult due to accessibility issues and it has to be controlled so that passive samplers are covered by the sediment during exposure.

- Potential use of alginate beads as a monitoring tool, shown in case study where they were tested alongside phytoplankton monitoring during dredging operations (Cabrita, M.T., et al., Optimizing alginate beads for the immobilisation of *Phaeodactylum tricornutum* in estuarine waters, Marine Environmental Research (2013), http://dx.doi.org/10.1016/j.marenvres.2013.03.002).

- Passive sampling results are less affected by physical characteristics of sediment than total concentrations determined by exhaustive extraction of sediment. However, where passive samplers are agitated with sediments then coarser sediments and shells may damage the passive sampler polymer. Control of weight of passive sampler before and after sediment incubation can check for this.

- Comparative studies of different silicone-based passive samplers (e.g. silicone coated glass jars, SPME fibers, silicone rubber sheets) for HOCs are needed to verify this technique, and differences between these.

- Passive samplers for sediments can further be applied to suspended particulate matter that was sampled in sediment traps.

- Passive sampling can be used to determine contaminant release during dredging for example – Sabine presentation. Passive sampling of HOCs at a disposal site for dredged sediment gave more consistent results (freely dissolved concentrations in sediment porewater) than traditional methods (exhaustive extraction resulting in total contaminant concentrations in sediment). May be related to normalisation methods used, for example, normalisation to organic carbon. To test this further would need to measure several samples at one site to record sample concentration inter-variability.

- Passive sampling results being used to produce thresholds and compared with WFD EQSs. For example, the Monitool project is providing these for metals.

- Passive sampling – misses peak of impact as measuring over a period of time, but also spot sampling can miss this too. Will need to understand the minimum sensible measurement time window and when the peak event is in relation to the sampling period in order to help get as close to recording maximum concentration released as possible. The earlier in the sampling period that the peak occurs, the less impact this will have on the concentrations measured since contaminants are desorbed again from the sampling material. A current research project (PASTraMi) funded by the German Environment Agency and conducted by the BfG (German Federal Institute of Hydrology) investigates these issues. The project report is expected next year.

Final Remarks

The interest in this workshop reflected the high interest and potential consequences that the inclusion of ecotoxicological data in decision frameworks have. Current status and knowledge with regard to different ecotoxicological methods, their inclusion in regulation and the experience with it, assessment frameworks in the light of the European Water Framework Directive and derivation of sediment quality criteria were discussed. Controversies with regard to the reliability of ecotoxicological tests have become clear and new methods with potentials for environmental assessment were presented and discussed. A number of joint activities were suggested and will result from this meeting of experts from different countries and with different backgrounds. The next meeting that is planned will be a workshop on the reproducibility of ecotoxicological data under the roof of the SedNet conference in 2021.

BACKGROUND DOCUMENTS

Report on the Workshop on Sediment Classification and Management Decisions – in situ and ex situ. Hamburg, Sept. 20-21, 2018.

OSPAR 2019 Audit of EACs

OSPAR Workshop EACs 2004

EU Guidance Document No. 27 Technical Guidance for Deriving Environmental Quality Standards Updated version 2018

Menchaca et al. 2013. An Empirical Approach to the Determination of Metal Regional Sediment Quality Guidelines, in Marine Waters, within the European Water Framework Directive.

Menchaca et al. 2014. Determination of polychlorinated biphenyl and polycyclic aromatic hydrocarbon marine regional Sediment Quality Guidelines within the European Water Framework Direct.