Contaminated sediments: useful tools for an integrated risk assessment framework

Contributions from OVAM

European Regional Development Fund

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Contents

Sullied Sediments

Sediment Assessment and Clean Up Pilots in Inland Waterways in the North Sea Region

Many of the inland waterways in Europe are under threat due to the introduction of Watch List chemicals that are not currently regulated under the European Water Framework Directive. These chemicals enter our waterways as a result of our day-to-day activities and through industry, and many have been shown to be harmful to wildlife and the wider aquatic environment. Regardless of their source, these pollutants accumulate in the sediments in our rivers and canals over time.

Water regulators and managing authorities do not always know the levels, locations or impacts of these pollutants. Nor do they have the tools to assess sediments confidently and make informed environmental management decisions. To address these issues, the Sullied Sediment project partnership of scientific experts, regulators and water managers is developing and testing new tools that will enable stakeholders to better assess, treat and prevent contamination from these chemicals. This work is being carried out at selected sites in the Elbe, Humber and Scheldt river catchments.

The intention of the Sullied Sediments project is therefore to help regulators and water managers make better decisions with regard to the management, removal and disposal of sediments, thereby reducing economic costs to private and public sector organisations, and the impact of these pollutants on the environment.

The partnership is also working to reduce the extent of chemicals entering the water system by raising awareness about what we, as consumers, are releasing into the environment through the use of common drugs and household products. This includes the involvement of volunteers in a sediment sampling initiative across the North Sea Region, which will inform and empower them as water champions in their local communities.

The Sullied Sediments project has been co-funded by the European Regional Development Fund through the Interreg VB North Sea Region Programme with match funding from the 13 partners involved. The project partnership includes public, private, community and voluntary sector organisations based in the United Kingdom, Germany, Belgium and the Netherlands.

The project has been supported under the Interreg VB North Sea Region Programme's third priority, which is focused on a Sustainable North Sea Region, and is led by the University of Hull (UK).

Website: northsearegion.eu/sullied-sediments

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Executive Summary/Abstract

This report is a summary of the different contributions from OVAM to WP3 and WP4 of the Interreg project Sullied Sediments. The initiatives are all situated within the goal of developing better decision tools on risk assessment and remediation of contaminated sediments. The contributions of OVAM are mainly desktop studies that bring together existing knowledge into new guidelines and tools that support decision making. See figure 1 for an overview and the relation of the different chapters.

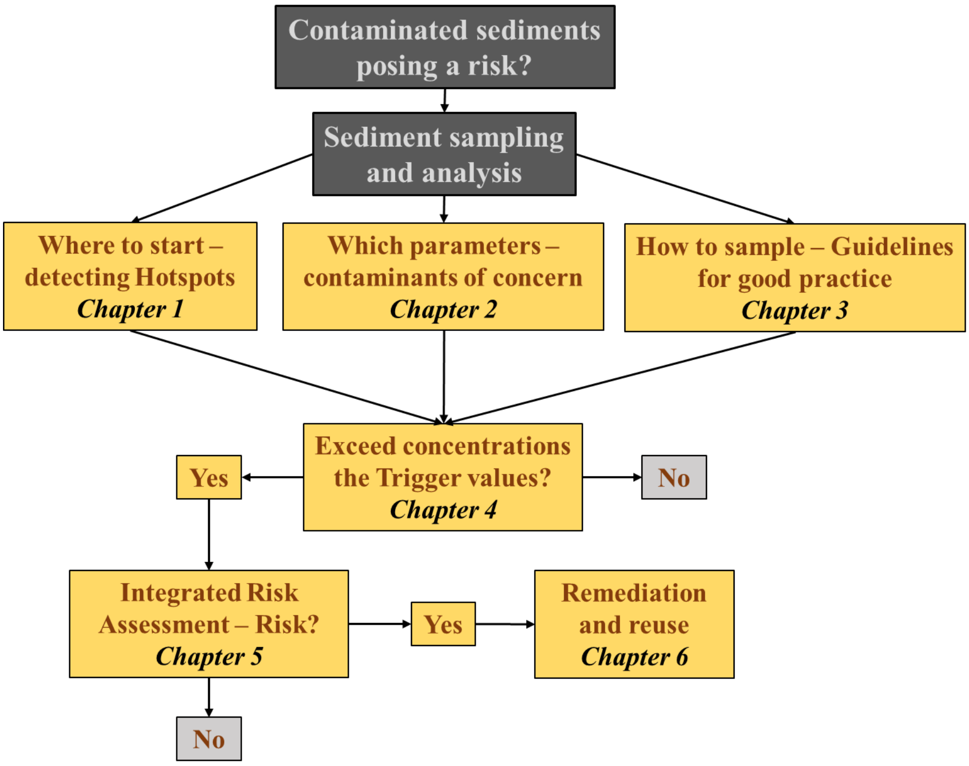

Figure 1: overview and the relation of the different chapters discussed in this report.

Introduction to paper

Why is tackling sediment pollution important?

The European Water Framework Directive (WFD) is the most important environmental directive for the protection of aquatic ecosystems (WFD-2000/60/EC). The aim of the directive is to secure water resources and to achieve good chemical and ecological quality for groundwater and surface water in Europe by 2027. Sediments are an important part of these aquatic ecosystem. It is a habitat for many benthic (micro)organisms and supports many ecosystem functions such as substrate for aquatic plants, is important in the biogeochemical nutrient cycles or serves as habitat and provides food for animals. Accordingly, when protecting aquatic ecosystems from the influence of anthropogenic pollution, it is important to consider sediments as well. In addition to the ecological objectives formulated by the WFD, specific requirements arising from user functions such as recreation, (professional) fishing, drink water supply or industry may also lead to the need for remediation.

The specific properties of sediments result in that most pollutants released into the aquatic environment adsorb to sediment particles. Therefore, sediments are considered to be the most relevant matrix for monitoring pollution in relation to the achievement of ecological targets within the WFD. After all, even if water quality improves, historical pollution might still be present in the waterbed and can act as a secondary source. In order to limit the impact of chemical pollution on aquatic ecosystems, it is important to identify the risks of contaminated sediments and to remediate the sites where the impact is unacceptable. However, risk assessment of contaminated sediments is complex and remediation can be very costly. In this respect and within the framework of the Interreg project 'Sullied Sediments' a number of initiatives to develop an integrated methodology to detect locations where sediments contamination has an unacceptable impact on humans or ecosystem and remediation is necessary. This report gives an overview of the various initiatives where OVAM has been involved and their role in the development of policy related guidelines on investigation and remediation of polluted sediments.

1. Identifying hotspots

Detecting sediment pollution, where to start?

As in most industrialized areas, a certain degree of sediment pollution is present in almost all European watercourses. In Flanders, large efforts on sampling and measuring sediment contamination has been made by the Flanders Environment Agency (VMM). This results in an extensive database with data on the ecological, chemical and ecotoxicological quality of more than 400 locations in Flemish waterbodies. However, the locations of this monitoring network have been chosen to map the overall quality of the aquatic ecosystems without taking possible risk activities into account that could cause high level of pollution on a local scale. Withing the framework of Sullied Sediments a methodology was developed to identify locations where an increased risk of serious waterborne pollution might be present (Arcadis, 2020). The costs associated with sediment investigations can be considerable, but also the costs associated with remediation of the waterbed can be very high. In order to cost-effectively map sediment contamination, (historical) activities which have a high risk to cause elevated concentrations of environmental pollutants, so-called hotspots, have been identified. In this context, only point sources were taken into account, while risk activities contributing to diffuse pollution were not included. In this study only hotspots in non-navigable watercourses have been investigated.
In order to identify sediment pollution hotspots, a list of 14 industrial sectors with recent or historical activities with elevated risk have been selected. The selection was based on:

(1) A list of industrial sectors with activities with elevated risks related to pollution of the watercourse compiled in the Netherlands.
(2) A database with all emissions from companies towards water bodies, required to report to the authorities (integrated annual environmental report, IAER).
(3) Expert judgement concerning historical activities. Reporting of emissions in the IAER database was only started in 2004 and the list of Dutch industrial sectors with a high risk starts at 1985. There are certain historical industrial activities from before 1985 which may have led to serious sediment pollution.

This resulted in the following list of 14 industrial sectors with elevated risk.

- Carbochemistry, including coking plants
- Petrochemistry
- Chemical industry
- Primary metal industry
- Waste management companies
- Cleaning and drum reconditioning companies
- Power plants
- Paper mills
- Shipyards
- Wood preservation
- Tanneries
- Textile dyeing
- Asbestos cement plants
- Asbestos paper mills

This list of sectors has been linked to registered locations where one or more of these risk activities are taking place or have taken place. In addition to the relevant sectors, sectors that produce, store or consume large quantities of priority chemicals have also been taken into account. This exercise resulted in a list of 208 different types of activities related to these 14 selected sectors.
This list of activities was then used to make an inventory of all the properties in Flanders where one or more of these 208 risk activities were carried out. However, this resulted in a list of thousands of plots, which made further prioritisation necessary. This prioritisation took place in three different phases in which the selection criteria have been adjusted each time on the basis of knowledge from the previous phase. The prioritisation resulted in the removal of a few activities that proved to be irrelevant. The following selection criteria were taken into account:

- The scale of the activities
- The period of the activities
- The duration of the activities
- Type of activities
- Distance from the nearest navigable and non-navigable watercourse
- The location of the plot, in particular whether the watercourse is situated in an ecologically valuable area (WFD)
- The type of research already carried out on a particular plot
- The number of activities linked to a plot, because different plots with activities with elevated risk adjacent to the same segment in a watercourse probably result in a higher risk of pollution.
- Expert judgement

Based on these criteria, a score was assigned to all the plots. The score was used to prioritize them with regard to the probability that the activities of the plot have caused serious sediment pollution. The plots with the highest risk where investigated further. This involved (1) a preliminary study based on existing data, (2) a site visit and interview with the watercourse manager and (3) could result in sediment sampling and chemical analyses. In the period 2017-2019, a preliminary study was started on almost 1000 unique locations. In 31% of cases the preliminary study resulted in sediment sampling and analysis of pollutants. For all these locations the following pollutants have been measured: Polycyclic, Aromatic Hydrocarbons (PAHs), Mineral Oil (MO), metals, Polychlorinated Biphenyl (PCB) and Organochlorine Pesticides (OCP), and site-specific pollutants where appropriate, based on the preliminary study.
The selection method based on activities with elevated risk does not take the specific characteristics of the site and the receiving watercourse into account. Yet, these may have a major influence on the presence of contaminated sediments. This means that a preliminary study that includes these aspects on a case by case basis is very important to assess whether a sampling campaign is possible or relevant. This includes, for example, information on recent dredging works, accessibility of the watercourse, or the size and flow rate of the receiving water body.

Conclusion

The list of activities with elevated risk is used as a basis for the identification of possible contaminated sediment hotspots. However, this list of activities cannot always unequivocally predict the presence of serious sediment contamination and therefore needs to be combined with expert judgement. The result is a methodology which makes it possible to rank a large amount of data according to the intended purpose. The method depends heavily on the quality of data and the lack of certain information can cause a site or watercourse to be wrongly assigned to a different priority. Furthermore, it is a generic prioritisation based on land-based activities and which does not take site-specific characteristics into account. Carrying out a preliminary study on a case-by-case basis therefore remains very important. On the basis of initial sampling and analyses it has already been possible to select certain risk activities which, in most cases, have resulted in sediment contamination. However, data on pollutant concentrations is still limited and, in order to draw well-founded conclusions, the list of activities with elevated risk of serious sediment contamination must be further validated by carrying out additional investigations with sampling and pollutant analysis. Sediment contamination is a complex and dynamic matter. In order to develop a cost-efficient policy framework, many future challenges remain.

2. Priority substances and contaminants of emerging concern

Contaminated sediments? Which substances should be analysed?

The previous chapter reviews a method that could be used to identify contaminated sediments based on available data. As was discussed, it is not possible or desirable to measure pollution in all watercourses. In the same way it is also not feasible to measure all possible chemicals that might be present in sediments. The quantity of various chemical substances that end up in the environment is large, and the costs associated with analyses can be high. Within the framework of Sullied Sediments, a methodology has been developed to rank substances according to the extent to which their presence in the sediment might pose a risk to the aquatic ecosystem (Ecofide, 2020). This prioritisation was carried out primarily for the 45 parameters put forward by the WFD as "priority substances" for pollution of aquatic ecosystems. These are substances for which there is already quite a lot of data available, in terms of properties, environmental concentrations and impacts.

To define which chemicals are important in terms of risk assessment of contaminated sediments various criteria have been used:

(1) A first selection was based on the physicochemical properties of the chemicals. Some substances tend to bind to the sediments stronger than others. This is represented by a substance-specific equilibrium constant (Koc or Kow) or by known properties of e.g. metals that cause them to bind strongly to sediments. The higher these equilibrium constants (Koc or Kow) are, the stronger the substance will bind to the sediment. A first step in the selection is to include only metals and substances with a log Kow greater than 3. As these pollutants bind strongly to the sediment, this is supposed to be a relevant matrix for monitoring these pollutants.

(2) For the second step, the concentrations of chemicals present in the sediment of Flemish watercourses have been examined. As already indicated, concentrations of pollutants are measured at more than 400 locations on a regular basis by Flanders Environment Agency. This extensive dataset was used to determine which of the "priority substances" are present in elevated concentrations in the Flemish water bodies. Elevated concentrations are defined as concentrations that exceed the sediment quality guideline (values reported in the WFD substance data sheet and Flemish trigger values (see chapter 5 for more information).

(3) Subsequently the extent to which substances are accumulated by biota (bioaccumulation) is taken into account. Because bioaccumulation indicates that the contaminants are bioavailable to aquatic organisms, possibly causing direct negative effects. An additional risk that is taken into account is that pollutants can accumulate in the food chain and concentrations might increase with the trophic level (biomagnification) resulting in possible negative effects on apex predators or humans. For several of the priority substances, those that are that are highly bioaccumulative, EU Member States are required to measure concentrations of pollutants in aquatic biota (fish or shellfish) and compare them with biota quality standards. The data on concentrations in these biota in Flanders were used to define whether these substances could be of risk when present in the sediment. If the biota standards are exceeded, this is a strong indication that the substance in question may also pose a risk for sediment dwelling organisms.

(4) Finally, the substances for which concentrations in surface water exceed the WFD standard were identified. Exceeding the standard indicates the presence of a risk, either ecological or human and (historically) polluted sediments can be a source for pollutants towards the surface water.

This selection methodology resulted in a list of 14 substances for which sediment pollution is expected to pose a significant risk to the aquatic ecosystem. These are substances that should be monitored in sediments and should be given extra attention when locating possible hotspots. It involves mainly substances which tend to accumulate in the sediments and for which monitoring data from Flanders indicate exceedance of the standard in at least two compartments (water, sediment or biota). For most substances the standards are exceeded in most of the watercourses in Flanders and are caused by diffuse pollution. The list of 14 substances consists of three metals (mercury, nickel and cadmium), 6 PAHs (fluoranthene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and anthracene) and the substances PFOS, heptachlor, brominated flame retardants (PBDEs), dioxins and tributyltin (TBT).

It was possible to establish this ranking due to the large amount of data available on these priority substances. For new or emerging substances, this exercise is much more difficult. However, there are many different chemical substances, including for example, pesticides, personal care products, medicines, plasticisers or flame retardants, which end up in aquatic ecosystems, accumulate in sediments or biota with potential ecological or human risks. However, knowledge about distribution or effects is still scarce, which makes risk analysis or prioritisation of these substances very uncertain. Several methods that define emerging contaminants with potential risks have been described in literature. An option, comparable to the methodology to define hotspots, is to prioritise emerging contaminants on the basis of an emission inventory. However, further research is needed in this field.

3. Sediment sampling

Monitoring for risk assessment of contaminated sediments: guidelines for good practice

A watercourse is a complex and dynamic system. The quality of the sediment is determined by the water quality, discharges into the watercourse, influx or removal of sediments, and various other biological and physicochemical processes. Most pollutants are associated with fine sediment particles and organic matter, which are deposited in certain areas of the watercourse. Since sedimentation and erosion processes are heterogeneously distributed in a river, also contaminant concentrations in the sediments can be very heterogeneous. Pollutants may also spread far from the source, including to banks and the surrounding land by floods or dredging operations. Consequently, investigating sediment contamination poses many challenges: For example, the choice of sampling locations has a major impact on the results. At the same time, a watercourse is a highly dynamic system, which makes defining the best sampling locations difficult. Moreover, sediments may contain a cocktail of contaminants, which makes it difficult to link the contamination to a particular source, partly due to the dynamic nature of the system. As a result, there are often many different administrative and legal stakeholders involved.

A guideline on research in contaminated sediment and river banks has been developed (Antea Group, 2020). This manual focuses on unnavigable watercourses and comprises practical guidelines to examine river sediments and related matrices, e.g. river banks, flood plains or groundwater. In Flanders, for investigation of navigable watercourses a customized monitoring program should be elaborated. The guidelines enable soil remediation experts to elaborate a research strategy for contaminated sediments. The strategy is determined by the objectives of the research and can be very diverse: (1) Define reuse possibilities of dredged sediments. (2) Define the level of contamination of sediments or banks of a certain stretch of a water course. (3) Determine the impact of waste water discharge on the watercourse and locate the source(s). (4) Determine the release of chemicals from contaminated soils or groundwater. In practice, the manual could be used e.g. within the framework of the exploratory phase of sediment investigation, a full risk assessment or for a technical report needed for dredging operations.

Different steps in the research.
The guidelines on research of sediments and river banks is a technical document that guides experts through the different phases of the research. All steps and essential information are listed in detail. Here we give a concise overview of the various components.

A first and important step consists of a preliminary study in which existing information is collected to define whether sediment sampling and analysis is needed in the exploratory phase of sediment investigation for a particular location. If there are indications that contamination and related risks are present, additional data should be collected from the study site:

(1) Administrative information.
(2) Historical research into possible human interventions on the watercourse and its immediate surroundings, including an inventory of waste water discharge, information on spills or dredging operations.
(3) Geological, hydrological and general characteristics of the watercourse and the immediate surroundings.
(4) An inventory of potential pollution sources such as authorised or unauthorised discharges, waterborne activities, spills or diffuse sources via groundwater, run-off or erosion.
(5) Available data on the chemical and ecological quality of the watercourse. A very extensive monitoring network exists in Flanders. This databank comprise information on surface water and sediments and includes chemical, biological and ecotoxicological quality of different locations spread over Flanders.

In this preliminary study, it is important to include on-site field observations. These observations in combination with the existing information enables the expert to determine in the best possible way the nature and possible risks of the contamination and the best sampling locations.

Sediment **sampling** and **analysis** is the following step in the survey. Based on the expectations related to the contamination a strategy for lab and fieldwork should be elaborated. The sampling strategy will depend on e.g. the type of watercourse and will determine how many and at which locations samples will be taken, which depth layers will be sampled and which substances will be analysed. The guidelines describe possible sampling strategies and techniques in detail. A final phase is the **interpretation** of the results and **evaluation** of possible risks. These steps are described in the following chapters.

4. Trigger values

Does the measured concentrations indicate that further research is needed?

Trigger values

Once the concentrations of pollutants in the sediments have been measured, it is necessary to assess whether these may pose ecological or human risks. However, risk assessment of (historically) contaminated sediments is very complex and it is neither desirable nor economically feasible to carry out a comprehensive risk analysis for all sites where pollution is detected. During the exploratory phase of sediment investigation, a first distinction is made between (1) sediments where the contamination is very unlikely to pose any ecological risks and (2) sediments where the measured contaminants may pose a risk and where further research is required. A first step is to evaluate the measured contaminant concentrations against a quality standard, a trigger value. If trigger values are exceeded further research is needed. Different methods to define trigger values exist. The choice of a particular method is determined, among other criteria, by the availability of data and the objectives. It is important to realise that it is impossible to derive a single trigger value for a certain chemical that can accurately predict the presence or absence of a risk under all circumstances. Environmental conditions can have a major impact on bioavailability and thus on the potential risks associated with the presence of the contamination. It is therefore a first step that determines whether further research into possible risks is needed.

Trigger values were derived, mainly based on data made available by the Flanders environment agency (UAntwerpen, 2020). For various chemicals, trigger values were derived based on the concentrations measured in all Flemish watercourses with good biological quality. Good biological quality was based on a macroinvertebrate index which takes species diversity, abundances and sensitivity of different taxa into account. Detailed information on the method used, values obtained, validation and feasibility tests can be found in the report on trigger values. Trigger values were derived for 73 different chemicals, including 12 metals, 17 PAHs, 10 PCB congeners, organotin compounds, brominated flame retardants and pesticides. As already mentioned, the risks of contaminated sediments cannot be fully understand based on total concentrations evaluated against their respective trigger values. The context and bioavailability of the pollutants must be taken into account. The approach that has been used to derive the trigger values is conservative. The consequence of the method that has been used is that there is not necessarily a causal relationship between concentrations of pollutants and the likelihood of effects. As mentioned before, exceeding the trigger values does not necessarily mean that ecotoxicological effects will occur, but that further research is needed.

Broader evaluation

Trigger values shall be used to identify locations where the probability that contaminants present in the sediments will cause a risk will be small. When trigger values are exceeded for at least one parameter, other criteria might indicate whether further research is necessary. In addition to the extent to which one or more trigger values are exceeded, different criteria are used which take into account environmental characteristics or the possibility of spreading. The procedure which will determine whether further research will be necessary takes into account e.g.: (1) the probability of human contact with the polluted sediments, (2) whether the polluted area is situated in a protection zone for drinking water, (or) located in a biologically valuable area, (4) situated in a flood-prone area or (5) whether the watercourse has been dredged with deposition of sediments on the river banks. The different decision criteria are linked to a scoring system. The sum of all scores is a measure of the possible risks related of the contaminated sediment determines whether further research is required.

5. Integrated risk assessment

Does the sediment contamination pose an ecological or human risk?

Literature

Contaminated sediments can have a negative impact on the functioning of aquatic ecosystem in various ways. (1) Pollutants may be directly accumulated by organisms living in close contact with the sediments, with possibly ecotoxicological effects as a consequence. (2) Predation on those benthic organisms may also cause the pollutants to bioaccumulate and enter aquatic and terrestrial food chains. (3) Different processes may allow the substances to migrate from the bed to the surface water, thus spreading further and also adversely affecting pelagic biota. (4) Contaminated sediments may also cause human toxicological effects through direct contact and ingestion of contaminated sediment or water, or through consumption of contaminated fish or crustaceans. These different risk pathways are inextricably linked (Figure 2). In risk assessment of contaminated sediments it is therefore important that different processes and risk pathways are investigated in order to achieve an integrated assessment. However, these processes are numerous and complex. In order to gain a better insight, a literature study on the main processes and variables determining the exchange of chemicals between sediments and surface water has been executed (ARCHE Consulting, 2020).

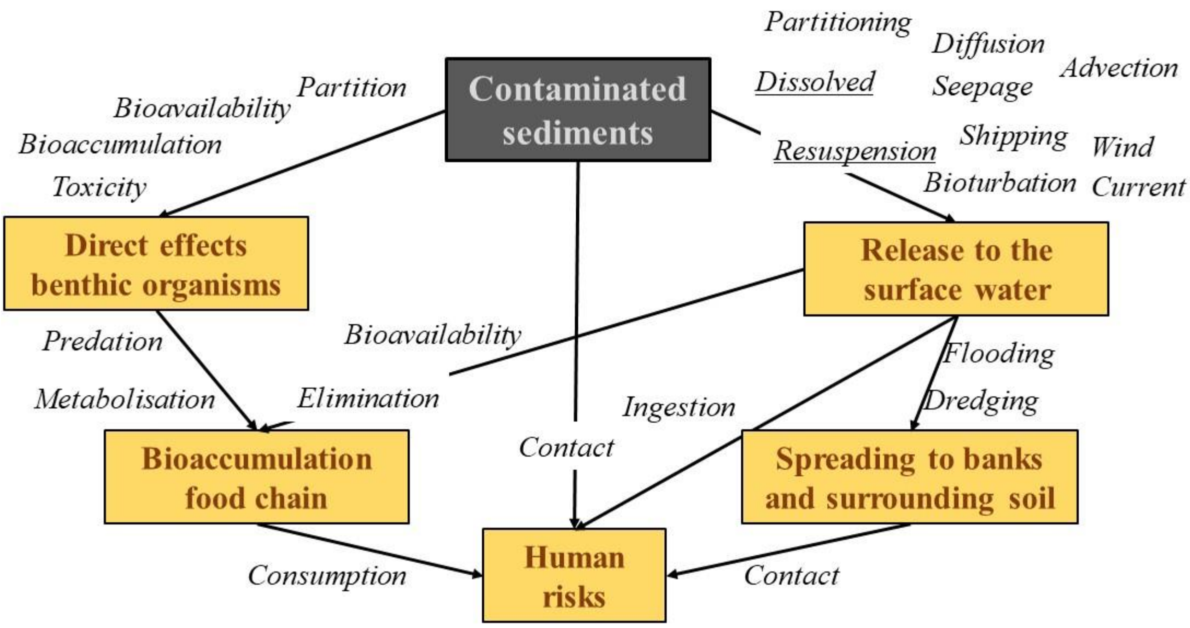

Figure 1: Risk pathways (frames) related to contaminated sediments and the most relevant, related processes (italics).

As a result of anthropogenic impact, many ecosystems around the world have been polluted. In recent decades numerous assessment frameworks have been developed which resulted in many different research and remediation projects. Information from these assessment frameworks has been collected in order to determine which concepts and techniques already exist and could be used to further elaborate the assessment framework in Flanders. In a literature study, six extensive assessment frameworks have been selected, briefly described, and compared based on their most important characteristics (Aecom, 2019). These are mainly implemented policy frameworks that give a description of the risk assessment procedures. The study includes the methodologies developed and implemented in Australia, Canada, United States (2), Norway and the Netherlands. The assessment frameworks are compared on the basis of (1) general methodology, (2) the use of sediment quality guidelines, (3) the extent to which background values and bioavailability are taken into account, (4) whether toxicity testing is included in the assessment and (5) to what extent parts of the methodology could be used for implementation in the Flemish guideline.

Many risk assessment frameworks for contaminated sediments focus primarily/exclusively on the sediments and barely take the entire aquatic ecosystem into account. As such, these methods are different from the methodology envisaged within Flanders, where processes and functions of the entire aquatic ecosystem will be considered. Policy frameworks in use in Norway and the Netherlands do focus strongly on the relation with the surface water and the risk of contaminant release from the sediment. The way in which dispersion is calculated and its role in risk assessment within these two frameworks was therefore explored in detail in the literature study (ARCHE Consulting, 2020). The risks related to the release of chemicals from the sediments are, in both assessment frameworks, mainly based on model calculations. These calculations are carried out in user-friendly spreadsheets and are based on generic constants which can be adapted to local conditions as knowledge of the system increases through additional research.

6. Remediation and reuse

What if remediation is needed?

The Waste Framework Directive currently requires the removal of contamination but existing treatment methods are costly and unsustainable. Ideally, sediments containing contaminants and posing an unacceptable risk should be remediated and as much as possible re-used. An 'end-of-waste' assessment of dredged material, initially expected to contain harmful pollutants, may demonstrate that it is, in fact, less hazardous than first expected. With reduced risks and disposal costs as a consequence, and a potent to identify opportunities for the re-use of these sediments. Within the framework of Sullied Sediments (WP 4) OVAM took the initiative to bring together information on management of sediments end-of-waste criteria for sediments and share experiences and knowledge on remediation.

Large volumes of dredged sediments need to be disposed of every year. Many valorisation routes have been mapped, but still too little sediment is finding its way to the market for beneficial use. The aim of this co-creation project is to look for new solutions for sediment policy (VLAKWA, 2020). The Flemish knowledge center Flanders (VLAKWA) focusses on the environmental, policy and legal aspects concerning the reuse of dredged sediments. To this end, an exploration has been set up from a systemic perspective. By identifying underlying mental models (in addition to events, patterns, etc.) , the deeper problems (with the associated opportunities) have been explored. This provided a widely broadened and enriched view on the factors that underlie a number of persistent mechanisms within this policy field and provides a broader view of possible causes. A non-exhaustive range of possible systemic levers has been listed throughout this report and may be explored further - preferably in a co-creative context .

The reuse or disposal of sediments is subject to a specific regulatory framework. The Flemish Region has harmonised the legal framework with regard to the reuse of sediments by integrating the reuse of sediments into the existing legal framework for the reuse of soil. The integration of the reuse of excavated soil in the soil legislation has been positive both on the practical side (harmonised and predictable framework for the sector) as on the environmental side (protection of the soil's functions for man and environment). The decision on how and where to reuse sediment is based both on the chemical and physical (technical) assessment. The potential for valorisation can be assessed on the basis of the successive aspects with regard to the theoretical, technical, economical and implementation potential. Subsequently, the cost of using this potential is compared with the cost of using other materials as a basis (SERTIUS, 2020).

A framework for risk analysis and risk management, both in situ and ex situ, with a focus on remediation and reuse has been developed to support watercourse managers to take informed decisions (WITTEVEEN EN BOS , ARCADIS, 2020). The methodology of the Flemish soil framework for deriving standards (soil remediation standards, values for free use, values for reuse as raw material) is used to assess possible threshold values for the reuse of sediments contaminated with contaminants of emerging concern. This framework makes it possible to place the use of these sediments in the end of waste framework. The report describes the development of a decision tool for the management of sediments contaminated with emerging contaminants. The decision system focuses on the Flemish soil framework, however, the principles on which this system is based are widely applicable in other standardization frameworks.

Not only contaminants of emerging concern need further investigation in an 'end-of-waste' assessments. The measured value of mineral oil in sediments often exceeds the threshold value for reuse. However, high concentrations of mineral oil can be caused by the presence of biogenic mineral oil instead of oil with a petrogenic origin. A procedure is validated to ensure that sediment samples are not wrongly classified as contaminated (SERVACO NV,2020). The clean-up technique for mineral oil in sediments and the removal of biogenic interferences has been investigated and validated. The procedure seems suitable for the analysis of sediment and soil samples with (slightly) elevated levels of mineral oil (cf. CAM/3/R.1) from places where contamination with mineral oil of petrogenic origin is very unlikely. With the application of the proposed clean-up method, it can be proved that the mineral oil is of biogenic origin.

A decision support tool (DST) for the remediation of contaminated sediments and riverbeds has been developed (WITTEVEEN EN BOS, DEC, ENVISAN, GENT DREDGING, 2019). Based on a questionnaire information on the conditions of a certain contaminated site is inserted in the support tool. This includes data on the type(s) of contamination, type of sediment, remediation goal, etc. and will help to select suitable remediation techniques. The desk study aims to provide tools to European sediment remediation experts, policy makers, industrial companies, waterway managers and private individuals to support decisions regarding management, removal and disposal of contaminated sediments, thereby reducing economic costs and the impact of contaminants on the environment.

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The reports are available from the website of Sullied Sediments and the website of OVAM (some only in Dutch).

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Acknowledgements

‘Sullied Sediments’ has been has been co-funded by the European Regional Development Fund through the Interreg VB North Sea Region Programme with a grant of 2.043.413 euros with equivalent match funding from the partners involved. The project partnership includes public, private and third sector organisations based in the United Kingdom, Germany, Belgium and the Netherlands

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Partners

The Sullied Sediments project partnership comprises 13 project beneficiaries:

Canal and River Trust (UK)

East Riding of Yorkshire Council (UK)

Ecossa (Germany)

Hamburg Port Authority (Germany)

Hamburg University of Applied Sciences (Germany)

Institut Dr Nowak (Germany)

Openbare Vlaamse Afvalstoffenmaatschappij (Belgium)

Radboud University (The Netherlands)

Socotec UK Ltd (UK)

University of Antwerp (Belgium)

University of Hull (UK)

University of Leeds (UK)

Vlaamse Milieumaatschappij (Belgium)

The partnership also receives expert advice from 12 strategic partners who form our Advisory Group:

East and North Yorkshire Waterways Partnership (UK)

Elbe Habitat Foundation (Germany)

Environment Agency (UK)

Federal Institute of Hydrology (Germany)

Foundation for Applied Water Research (Europe)

Hamburg Ministry of the Environment and Energy (Germany)

Northumbrian Water (UK)

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