



LIFE Project on Contaminated Sediments

LIFE99 ENV/NL/000263

Summarizing report

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Executive summary

Background

Since the discovery of contaminants in sediments in the early eighties, much emphasis has been placed on assessment of risks of the contaminated sediments, in the development of policy and legislation and in the development of techniques to clean and re-use sediments. Because these developments mostly took place at a national level, differences now exist between the different European countries.

Nevertheless, the problem of contaminated sediments is more of a river basin problem, than a national problem. The differences hamper the tuning of the management of waterways and an approach on sediments, which was especially recognized by the International Commission for the Protection of the Scheldt (ICPS) and the International Commission for the Protection of the Meuse (ICPM) that are established to tune water management at a river basin level. Both the ICPM and ICPS consider (transport of) contaminated sediments in their action programmes. Confronted with the differences in knowledge and applied science, and the lack of common methods and references, they decided to start the LIFE-project on contaminated sediments.

In the LIFE-project on contaminated sediments, the first steps were taken to tune the management of contaminated sediments in an integrated technical and administrative-juridical manner. This included integration between several technical and juridical disciplines at international scale (two river basins covering four countries/regions; Flanders, France, the Netherlands and Wallonia). The notion of contaminated sediments being a river basin problem, gained strength during the project, which ran parallel with the last steps in the coming about of the Water Framework Directive.

Common method for assessment of sediments

One of the first steps taken in the making of a common river basin management is to reach an agreement on the present state of the river system (in this case: on the state of the sediments). A major part of the LIFE-project therefore consisted of formulating a common method for sediment quality assessment, which was tested on four locations in the Scheldt and Meuse catchments. This so-called 'common method' gives recommendations for the methods of sampling sediment and for the analysis parameters in the samples. The assessment of sediment depends on the final objective; for purposes of monitoring the ecological quality, a triad approach with physico-chemical, ecotoxicological and biological assessment is the most appropriate. For maintenance purposes (i.e. dredging a fairway) physico-chemical assessment, combined with specific bioassays will satisfy.

There is broad agreement among the participants on the parameters for physico-chemical analysis. A small list of parameters requires further discussion and research. The choice for the tests within the ecotoxicological assessment and for the biological classification system could not yet be made based on the limited dataset of the project. The sites on which several tests have been performed for evaluation had the same (poor) quality, which made it impossible to reach conclusions. However, a team of specialists agreed upon a proposal for both the ecotoxicological as well as the biological assessment method. In order to come to definite conclusions and to put up reliable common standards, more data is needed.

Field tests

In order to evaluate the draft common method, three sites were tested twice during the project (Mortagne, Bossuit (both Scheldt) and Lixhe (Meuse)). According to the results of the triad-approach, the sites were polluted and even toxic, varying from moderately (Mortagne) to severely toxic (Bossuit and Lixhe). The site added during the second measuring campaign in order to make a comparison with a less polluted spot (Grembergen), was less polluted indeed, but still showed moderate effects on the testing organisms and was classified as 'poor quality'.

Possible solutions

To evaluate the feasibility of objectives in a management programme, insight in possible solutions for problems with contaminated sediments is a prerequisite. Therefore, a database was formed with international information on dredging, treatment and disposal of contaminated sediment. Added to this database was a decision support system to help determine the different techniques. The DSS applied to the results of the testing sites mentioned above, recommended storing, embanking or treating the sediment thermally.

Legal and regulatory aspects

The regulatory systems of, on the one hand, Flanders and the Netherlands and, on the other hand, France and Wallonia present significant differences when it comes to their approaches to contaminated sediment. In Flanders and the Netherlands on the basis of statutory provisions, contaminated sediment in situ is regarded as an environmental problem for the riverine ecosystem. In France and Wallonia, this is not the case, while the focus lies on the receiving environment (ex situ). Most other differences in the regulatory frameworks can be attributed to this basic difference in philosophy. In practice the differences, however, are somewhat less pronounced, and convergent trends can be identified.

A common knowledge base of divergent and convergent trends is important both because it offers a basis for further cooperation and because it provides a more thorough understanding of why the negotiating positions of the participating countries/regions differ. The divergent trends can be of assistance in identifying topics that might be less fruitful as a focus for seeking cooperation. Those issues that confront each of the four countries/regions with similar practical problems as well as those issues identified as common concerns, probably offer the most fruitful elements for further cooperation through a step-by-step approach.

An issue that merits further attention, and that could be the first subject of the step-by-step approach, is the nature of the standards used to monitor and classify sediment. This is a topic that can be addressed through cooperation at the technical and scientific level. The participants on the LIFE-project also worked, very enthusiastically, at this level, and they are of the same opinion, that the cooperation with the other participants was interesting and stimulating.

For the river basins in question, the results of further work can be used to define the objective of 'good ecological status' and to prepare an inventory of the status of the sediment. Thus, it would provide a basis for implementing the EC Water Framework Directive. Furthermore, it is important that this topic be addressed in the short term, as it will ultimately provide the basis for developing a common philosophy for dealing with contaminated sediment.

One topic that requires consideration, in the short term, is the relationship between upstream and downstream locations. The Water Framework Directive requires a river basin management approach. This implies that policies for contaminated sediment and dredging for those sediments in upstream locations would have to take into account the effects on downstream locations, including downstream locations in another country/region. Moreover, the question of the allocation of financial resources within the river basin management approach merits attention. Should such resources be allocated on a country-by-country basis or on the basis of the river basin as a whole? This is a sensitive issue as it raises considerations with respect to the "polluter pays" principle. While these considerations are not irrelevant, they should not bar the development of sustainable river basin management in a trans-boundary context. This is especially the case if, also in terms of the benefits for the downstream state, an euro spent upstream may be more efficiently spent than the same euro spent downstream.

Recommendations

The following strategies are recommended:

1. This report recommends, on the short term, to develop a common monitoring system and common standards for the classification of sediment in a step-by-step approach. The common monitoring system and the common standards can be used, among other things, to define the objective of 'good ecological status' in the Water Framework Directive and to prepare an inventory of the status of sediments in the Meuse and Scheldt basins. In the longer term, it might be recommendable to adjust regulatory frameworks, at which stage harmonizing those frameworks could also be considered.
2. Applying the common method on the Meuse and Scheldt basin could develop a common standard, because more types of sediments – also less polluted sediments – would be assessed. In this manner, an inventory of the status of the sediments in the basins is made in the same time. With a broader inventory, the Decision Support System can also be refined.
3. The inventory will be useful to select priorities in tackling the problem of contaminated sediment, and might give indications for emission reduction. In the more distant future, sediment transport

models and erosion models could be added to the inventory, in order to make the priorities stand out in sharp relief within a river basin approach.

4. The development of a strategy, by the ICPM and ICPS, to address the problems presented by contaminated sediment during the elaboration of the second Action Plans for the Meuse and Scheldt. This strategy could also link the Water Framework Directive to sediment transport.
5. Within the course of implementing the EC Water Framework Directive, and in the development of the 2nd action programmes of the ICPM and ICPS, the following topics deserve consideration:
 - On the short term, the identification of sediment polluting parameters of concern, in order to identify the need for (additional) programs and measures for point and diffuse sources for these pollutants,
 - On the short term, to establish guidelines for dredging operations and the treatment/deposition of sediments originating from maintenance operations in waterways (main river, harbours, relevant tributaries and canals),
 - On the mid-term, to establish guidelines to deal with contaminated sediment that will facilitate attaining the objectives of the Water Framework Directive, including guidelines that address the (potential) danger presented by transport of contaminated sediments to ecological valuable areas in the river basin,
 - On the mid-term, the manner in which the basic philosophies underlying the regulatory systems of the four states/regions can be brought into closer harmony with each other, and
 - Economic and financial aspects of the river basin management approach, for example by adding sediment management and dredging operations as an item within the economic analysis of the River Basin Management Plans.
6. The establishment of expert-groups on sediment by the ICPM and by the ICPS to implement the recommendations 1 to 5. At this stage of development of general tools – like a common monitoring system – it could be advantageous for the ICPM and ICPS to combine forces.
7. It is recommended to the European Commission, to address the problems encountered in finding sustainable destinations for dredged materials that are related to the classification of dredged material as waste, with a view to developing a special management system for those materials, either as a special category under the EC Waste Directive or as an exception to that Directive. The European Commission is also recommended to strengthen the role of the EC Water Framework Directive in the management of sediment.
8. Finally, it is recommended to disseminate the findings of the project – among other ways – by Internet site, which in turn would be linked to an existing structure or organisation for ease of addressing maintenance queries.

1 Introduction

1.1 Background

The LIFE-project on contaminated sediments finds its origin in the work of the International Commission for the Protection of the Scheldt (ICPS) and the International Commission for the Protection of the Meuse (ICPM). Since the discovery of contaminants in sediments in the early eighties, much effort has been put in the assessment of risks of the contaminated sediments, in the development of policy and legislation and in the development of techniques to clean and re-use sediments. Due to the fact that these developments mostly took place at a national level, differences exist between the various European countries. These differences hamper the tuning of the management of waterways and an approach on sediments, especially for international, border crossing waterways like the Meuse and the Scheldt (this explains the interest of the ICPM and ICPS). The notion of contaminated sediments being a river basin problem, gained strength during the project, which ran parallel with the last steps in the evolution of the Water Framework Directive.

In the LIFE-project on contaminated sediments, the first steps were taken to tune the management of contaminated sediments in an integrated technical and administrative-judicial manner. This integration between several technical and judicial disciplines at this scale (two river basins covering four countries/regions; Flanders, France, the Netherlands and Wallonia) reflects the innovative character of the project.

One of the first steps to take in the making of a common river basin management is to reach an agreement on the present state of the river system (in this case: on the state of the sediments). A major part of the LIFE-project therefore consisted of formulating a common method for sediment quality assessment, which was tested on different locations in the Scheldt and Meuse catchments ('common method'; see chapter 2).

In order to evaluate the feasibility of objectives in a management programme, insight in possible solutions for problems with contaminated sediments also is a prerequisite. In the project, an overview of methods of dredging, treatment and possible uses of contaminated sediments was drawn up. Also, a decision support system was developed to facilitate the choice for one of the methods in a specific case. This decision support system was applied on the sites used for the testing of the common method (see chapter 3).

Finally, the measures and solutions deriving from the objectives must fit within the policies and judicial structures of the countries involved. Both ICPS and ICPM have encountered difficulties in developing common approaches to contaminated sediment as a result of lack of insight into the policies and regulatory frameworks of the four countries. Chapter 4 focuses on legal and regulatory aspects relevant to policies regarding contaminated sediment.

These first steps in the direction of a common river basin management could derive considerable environmental benefits; if countries agree on rational sediment management and consider measures at a river basin scale rather than at a national scale, it could be imaginable that funds are generated at river basin scale to sanitize the most contaminated sites with high priority.

1.2 Method of working

The LIFE-project was executed in four themes, each in turn coordinated by one of the countries/regions involved. Theme 1 (The Netherlands) concerned with the legal aspects and regulations for dealing with contaminated sediments. The information needed was collected by desk-study and interviews, and thereafter discussed by all partners during two workshops. Theme 2 (Flanders) developed the common method for sediment quality assessment, in close cooperation with theme 3 (Wallonia) which tested the first drafts of the method at four field locations. After the two sampling campaigns within theme 3, the common method was discussed with all partners and adjusted by theme 2. Theme 4 (France), finally, made an inventory of techniques that internationally exist for dealing with contaminated sediments, as well as a decision support system to facilitate the choice between the different solutions when facing contaminated sediment in practice.

The themes all worked with a team of representatives from the four countries/regions. The results from the themes were regularly discussed among the theme-coordinators, as well as with all other partici-

pants during several workshops. Annexe 1 contains a list of persons and organisations involved in the project.

The final reports from all themes are to be found on the Cdroms attached to this report. An exhaustive list of reports and other products is put into annexe 2.

2 Getting better insight into the problem

2.1 Introduction

In order to get a shared insight in the condition of the sediments in the Scheldt and Meuse river basin, it is necessary to gear the methods of sediment analysing to each other, as well as the evaluation of the results. Or, in other words, there should be a common understanding on what is meant by 'contaminated sediment'.

During the LIFE-project, a comparison was made of the methods for monitoring and assessment of contaminated sediment that are used today in the participating and neighbouring countries. Therefore, an overview of the methods currently in use for the assessment of sediment quality in Flanders, France, the Netherlands and Wallonia was drawn up. Based upon the overview, a proposal for a common method was drafted (2.2) which was tested in four locations in the Scheldt and Meuse basin (2.3). Several topics, which were points of discussions or were unclear, were worked out in case studies (2.4).

2.2 Common method

The common method developed in the LIFE-project began starts with the question on the objective of the sediment quality assessment (2.2.1). Next, agreement was reached upon on the methods of sampling as well as the tests that should be performed on the sampled material (2.2.2 – 2.2.5). The method described in the following paragraphs was established after the testing of the draft common method in the field experiments (2.3).

2.2.1 Global assessment

The need for global assessment of sediment quality is a derivate from:

- Maintenance reasons, related to the removal of sediments at locations where nautical or hydraulic functions are threatened;
- Reasons of ecological quality, related to insight in the development of the quality of sediments and the relations of the sediments with the river water and the surrounding environment (see figure 2.2).

Until now, sediment quality assessment is mainly performed at locations where nautical or hydraulic functions are threatened by sedimentation. Therefore, the sediments must be removed. Prior to the removal, the sediment will be assessed based upon a list of physico-chemical parameters. With the result of the assessment in hand, a choice can be made between disposal or a certain way of remediation (see also chapter 3). Depending on the remediation technique or the disposal site it is recommended to test the sediment for toxicity with specific bioassays. Probably also other physico-chemical tests are necessary before a final decision can be made as to what to do with the dredged material.

Global assessment for purposes of monitoring ecological quality is best done by a triad approach, which means that physico-chemical measurements, bioassays and biological assessment are included in the assessment (see figure 2.1). Sediment quality assessment as part of a

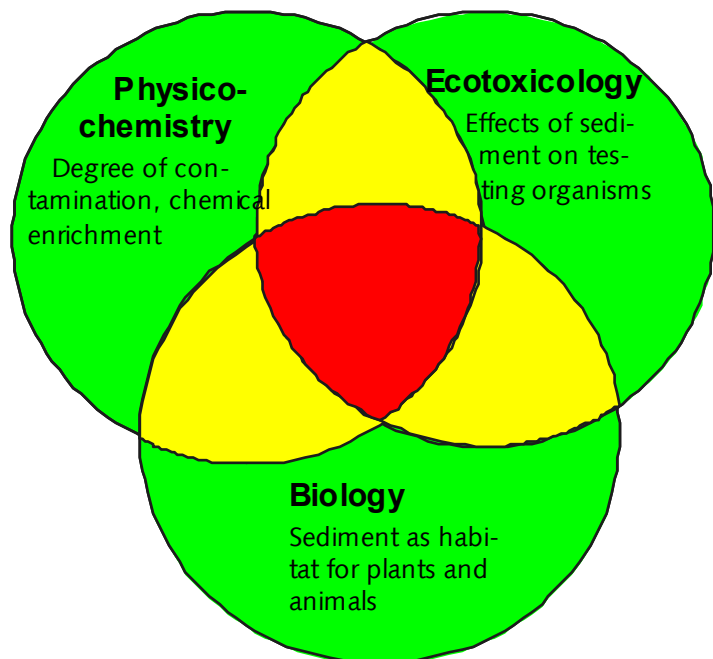


Figure 2.1: Global assessment by a triad approach. Colours indicate: good quality (white); moderate quality (green); poor quality (yellow); very poor quality (red)

regular monitoring program has so far only been carried out in Flanders. The initial comparison of the Dutch and Flemish triad approaches, performed on the results of the field-testing, showed a similar result for the final classification. However, the data was limited and all locations had a similar type of sediment (sc. heavily contaminated), so the discernment was not well tested.

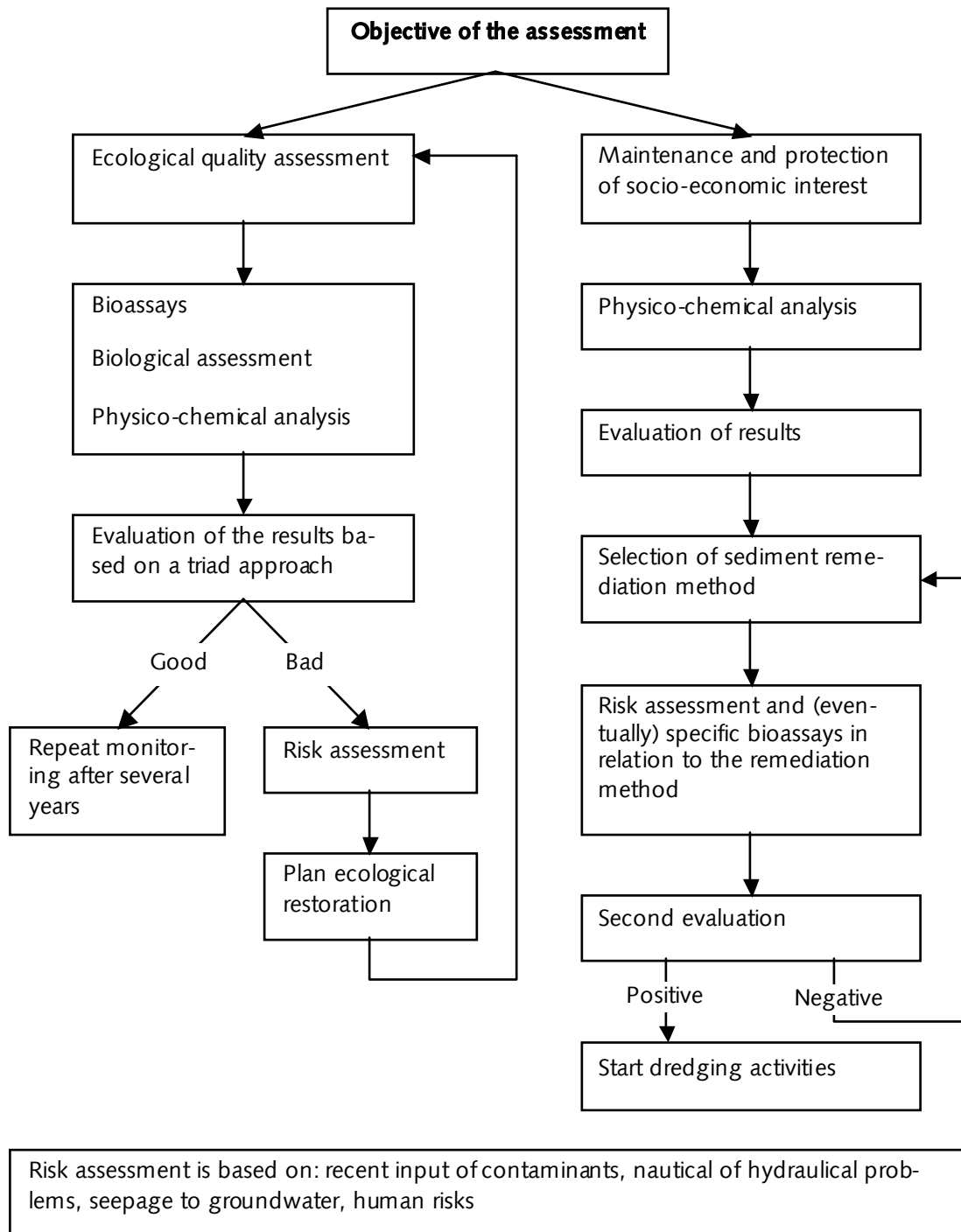


Figure 2.2: Schedule for assessment of sediments

2.2.2 Sampling, transport and storage

In monitoring research, primarily the biological active layer must be studied, which means the upper 15 to 20 cm. The easiest way to sample that layer is with a grab sampler like the Van Veen or the Ekman-Birdge. The grab sampler is the best device because it is easy to handle, it can be used in both small streams and large rivers, and it is easy to collect substantial amounts of sediment in a short period. Further, the device may disturb the samples because individual samples will be homogenised before analysing. The 6 litres Van Veen grab was chosen for in the common method, because it proved to be the best grab sampling apparatus in large systems, such as the rivers Scheldt and Meuse. The sampling pattern depends on the width of the river. A total amount of approximately 50 litres of sediment must be taken; the result of 8 to 10 individual grabs. Collected grabs must be mixed and subsequently the sediment can be divided for the different analysis. In contrast to monitoring processes, information about the vertical distribution of contaminants is required for managerial purposes. Therefore, it is recommended to sample the whole sediment layer (see figure 2.2) with the help of a core sampler.

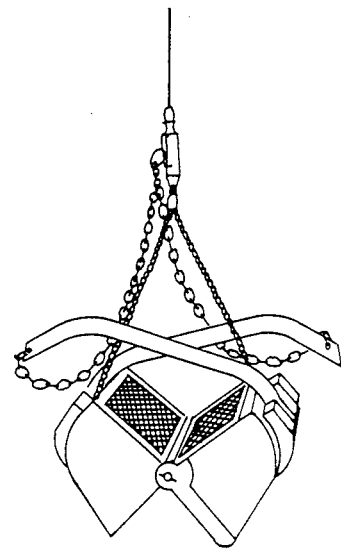


Figure 2.3: Van Veen grab sampler

Following the national sediment sampling programs, polyethylene buckets and/or glass bottles are used for transporting the sediments. Because the bioassays and the biological evaluation need a great amount of sediment, plastic buckets are for the recipients most easy to handle. For the physical-chemical parameters, glass bottles will be used.

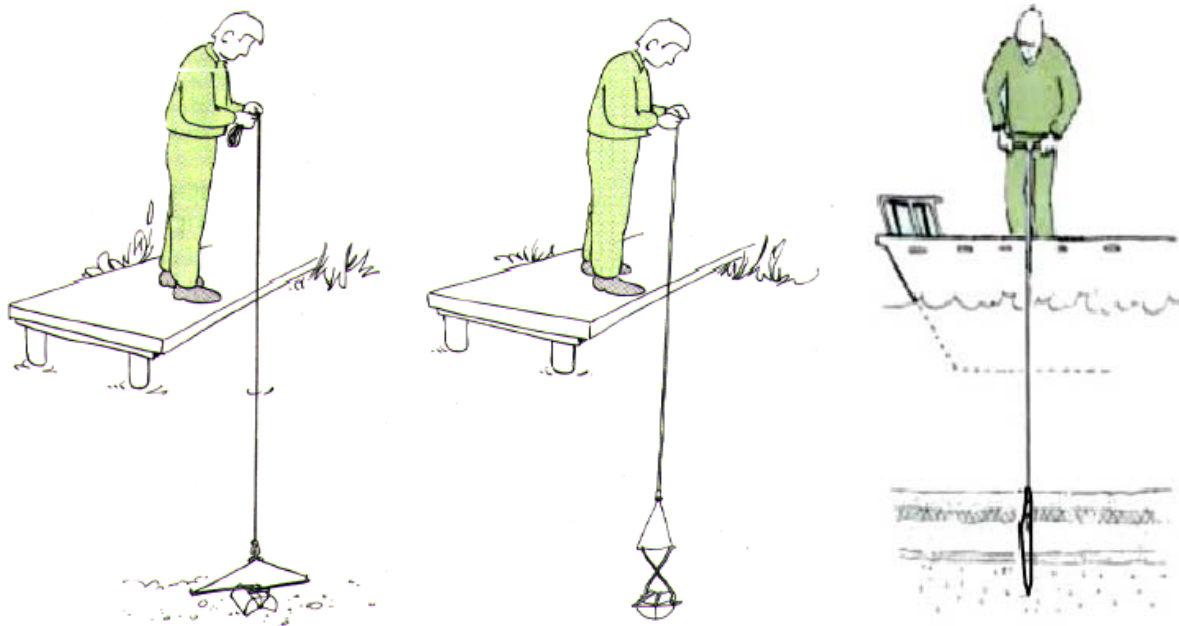


Figure 2.4: Sampling; Van Veen grab sampler

Peat sampler

Regarding the transport from the sampling point to the laboratory and the storage, it is recommended that the samples be kept at a temperature of 4°C and to analyse as soon as possible. In case of bioassays on pore water, extraction and analyse of the pore water must be done just before the start of the test. The method for the pore water extraction will be centrifugation.

Maximum storage time of sediments for bioassays or bioaccumulation tests is 6-12 weeks. The storage time regarding chemical analyses varies. The sediment can be freeze-dried when total extractions are carried out, like for analysis of heavy metals.

2.2.3 Physical-chemical analysis

Based on the arguments that not all contaminants will be a problem everywhere, it was decided to make up two lists. The first list contains the physico-chemical parameters that have to be measured always at all sites (table 2.1). The second list is a list of optional parameters that can be included in the monitoring within a certain region or river (table 2.2). The choice whether or not to include elements from table 2.2 is best made with information on sources of emission of the specific contaminant within the river catchment. The list in table 2.2 also contains a number of contaminants from which the behaviour in sediments is not well known yet. Therefore these contaminants need to be better characterised. A first trial is given in the case study described in chapter 2.4 and annexe 3. So far, there is no legislation concerning the assessment of sediments. Sediments have to be analysed only when the material is removed from its site. The parameters to be measured are usually based upon lists of parameters required to analyse in contaminated soils (i.e. not under water, but soils ashore). However not all measurements are useful for sediments unless the material is disposed at land. Therefore the proposed list differs from the lists that are currently used.

Table 2.1: The physical and chemical parameters proposed to include in the physico-chemical assessment of the monitoring in the rivers Scheldt and Meuse.

	Parameter	Remarks
1) <u>Field measurements</u> <i>water column</i>	- Temperature - Dissolved oxygen - Oxygen saturation - Electrical conductivity - pH	Water sample is taken from the surface
2) <u>Global measurements</u> <i>sediment</i>	- Grain size distribution - Dry matter content - Total organic carbon (TOC) - CEC - redox potential of the sediment	Grain size distribution can be analysed with laser diffraction, however the pipette method is more accurate for the finest fraction.
<i>Interstitial water</i>	- pH - Dissolved organic carbon (DOC) - Chromium VI	
3) <u>Heavy metals and metalloids</u>	- Arsenic (As) - Cadmium (Cd) - Chromium (Cr) - Copper (Cu) - Iron (Fe) - Lead (Pb) - Manganese (Mn) - Mercury (Hg) - Nickel (Ni) - Zinc (Zn)	Chromium VI is measured in the interstitial water. It is suggested to analyse also the concentration of the other metals in the interstitial water. See for extraction methods also 2.4.
4) <u>Inorganic parameters</u>	- Phosphorus - Total nitrogen - Nitrates, nitrites and ammonia - Sulphate	The Williams extraction method is the best method for the determination of different phosphorus fractions (Vanhoof et al., 2001; 2.4)
5) <u>Organic micropolluents</u>	- Non polar hydrocarbons - EOX (extractable organohalogens)	

Sum organochlorine pesticides		
-	Alpha hexachlorohexane (hch)	
-	Beta hch	
-	Gamma hch (lindane)	
-	Hexachlorobenzene	
-	Heptachlor	
-	Heptachloroepoxide	
-	OpDDD (2,4-DDD)	
-	PpDDD (4,4-DDD)	
-	OpDDE	
-	PpDDE	
-	OpDDT	
-	PpDDT	
-	Aldrin	
-	Dieldrin	
Sum Aldrin Dieldrin		
-	Isodrin	
-	Endrin	
-	Alpha endosulfan	
-	BTEX (Benzene, Toluene, Ethylbenzene, Xylene)	Phenol can be best analysed with GC/MS after derivation with acetic acid anhydrid (Van Deun et al., 2001, chapter 4.3)
-	Styrene	
-	Phenols	
-	<i>Seven PCB's</i>	
-	PAH 's 16 of EPA (6 + 10)	

Table 2.2: The optional physical and chemical parameters. An "A" means: proposed to include in the monitoring program of certain areas, an "S" means: parameter that needs further study.

	Parameter	Remarks
2) <u>Global measurements sediment interstitial water</u>	- Basic cat ions	A
	- CaCO ₃	A
	- Heavy metals	S
	- AVS-SEM	S
3) <u>Heavy metals and metalloids</u>	- Cobalt (Co)	A (for example: Meuse)
4) <u>Inorganic parameters</u>	- Cyanide	A (for example: Meuse)
5) <u>Organic micropolluents</u>	- organophosphorus pesticides	S
	- triazine herbicides	S
	- urea herbicides	S
organo-metallins		
-	organotins	A (for example: harbours)
-	organomercuries	S

2.2.4 Ecotoxicological tests

The use of bioassays and the bioassays used, differ in the regions. The participants of the project agreed not to choose one test, but to recommend a battery of tests. The selection of suitable tests within this battery depends of the aim of the study (see table 1; annexe 3). The aim of this study was monitoring within a river basin (prioritisation), so the participants recommend that the battery contained at least an acute pore water test, a chronic pore water test and a sediment contact test. The organisms used have to be relevant for the system and the bioassays have to be standardized. A panel of experts out of the four regions suggested the following battery within this project: acute pore water test with *Raphidocelis subcapitata* (freshwater algae), *Vibrio fisheri* (bacterium) and *Thamnocephalus platyurus* (fairy shrimp), a chronic pore water test with *Daphnia magna* (waterflea) and the sediment contact test with *Chironomus riparius* (midge) and *Hyallela azteca* (amphipod).

Most of the bioassays are already standardized in one of the regions. However, standardisation of the whole procedure of the different bioassays, including the use of reference sediments, must be considered at European level.



72h growth inhibition test with *Raphidocelis subcapitata*



16-day pore water test with *Daphnia magna*



10-day sediment contact test with *Hyallela azteca*

Figure 2.5: Three test organisms out of the different tested bioassays

2.2.5 Biological classification

The biological classification can be best done based on the whole macrobenthic community. However, the determination to species level is time consuming and is sometimes very specialistic work. Besides this, a list of species is very hard to interpret for water managers and policy makers. Therefore, the use of (combined) indices is favoured. So far two indices seem to be very promising, namely the oligochaete index (IOBS) in combination with the oligochaete-density and the % *tubificidae* with or without setae, and the biotic sediment index (BSI). However, these methods need to be used on a broader international scale to make a better evaluation. In the current project, too few samples have been examined and the variety in overall sediment quality was too low in order to select the best biological assessment methodology.

2.3 Field tests

2.3.1 Locations and sampling method

The draft common method was tested in two campaigns at 3 respectively 4 locations (see figure 2.6). In the choice for the locations, it was considered whether testing of a lot of locations or testing of a lot of methods should be preferred. With a choice for testing more methods, it was useful to – at least – test locations with a high toxicity, in order to evaluate the tests indicating acute toxicity. Therefore, during the first campaign samples were taken at Lixhe (Meuse), Mortagne and Bossuit (both Scheldt); sites with a known bad sediment quality. Nevertheless, in order to be able to make a better comparison of the ecotoxicological and biological tests, during the second campaign,1 a site was added with an expected improved quality (Grembergen, Scheldt).

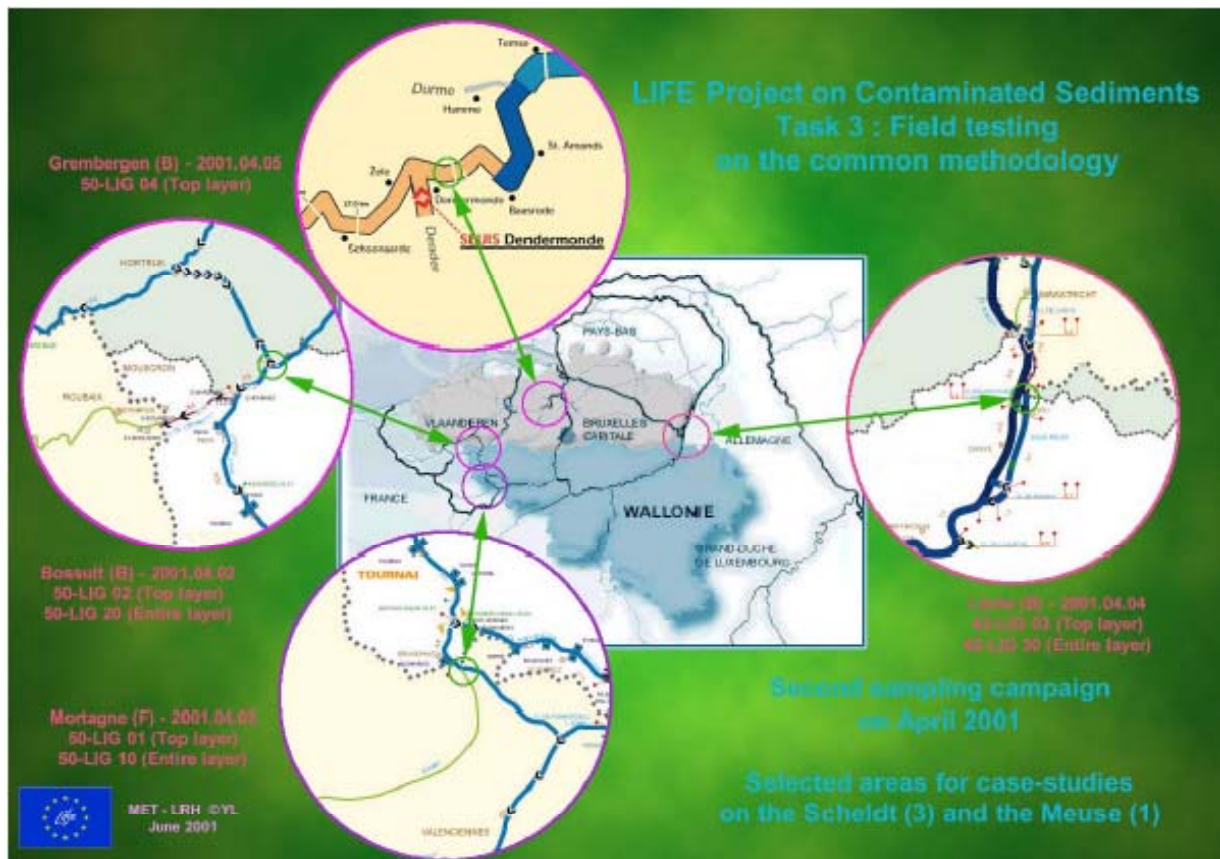


Figure 2.6: The four test locations

For each site, the sampling concerned the top layer with a Van Veen grab and the deep or entire layer with a peat sampler, except in Grembergen where only the top layer was sampled. For each location, 70 (first campaign) to 100 litres (second campaign) were collected; enough material to carry out the physico-chemical and ecotoxicological analysis. With the peat sampler, about 18 litres of the deep layer were collected to realise only physico-chemical analysis.

Apart from these, samples were taken for the case study on the comparison of four biological assessment methods (see also 2.4).

2.3.2 Physico-chemical results

In none of the locations cyanides, MAH's, BTEX, halogenated solvents or organochlorinated pesticides were found. In Bossuit, the fluoride concentration is very high, especially in the top layer. Concerning the contamination with heavy metals, there are always traces of contamination, except for Grembergen. In Lixhe, cadmium is found at high concentrations, in Bossuit chromium and cadmium, and in Mortagne copper (the latter only in the deep layer). For organic compounds, a similar situation is discovered. In Grembergen, there was no or few sign of pollution, but everywhere else contaminations were obvious. Total hydrocarbons were always found at a high concentration (>1.000 ppm). In Lixhe, PAH's and PCB's were the most concentrated. In Bossuit, the sediments contained the highest concentration in total hydrocarbons and in total aliphatic hydrocarbons, especially in the entire layer.

2.3.3 Ecotoxicological results

The following bioassays were conducted:

- **Acute pore water test**
 - *Raphidocelis subcapitata* (freshwater alga)
 - *Vibrio fischeri* (Microtox®; bacterium)
 - *Thamnocephalus platyurus* (fairy shrimp)

- **Chronic pore water test**
 - *Daphnia magna* reproduction test (water flea)
- **Sediment contact test**
 - *Hyalella azteca* (amphipod)
 - *Chironomus riparius* (midge)

Based upon these evaluations, the samples from Bossuit and Lixhe are considered severely toxic, from Mortagne as moderately toxic and from Grembergen as not toxic.

2.3.4 Biological classification

Two biological assessment methods have been done at the sampling sites, namely the Biotic Sediment Index and the method based on the Oligochaete community. The results are presented in table 2.3. The quality at the sampling locations varies from very bad to poor/moderate. The biggest difference between the assessment result of the two methodologies is found at Lixhe. However, the dataset is too small to compare the two assessment methods.

Table 2.3: Results of the biological assessment

Sampling station	Sampling date	Oligochaete community	BSI
Lixhe	10/11/00	Bad quality	Very bad quality
Lixhe	04/04/01	Poor quality	Very bad quality
Mortagne	06/11/00	Bad quality	} Moderate quality
Mortagne	06/11/00	Bad quality	
Mortagne	06/11/00	Poor quality	} Moderate quality
Mortagne	03/04/01	Bad quality	
Bossuit	06/11/00	Very bad quality	Very bad quality
Bossuit	03/04/01	Bad quality	Very bad quality
Grembergen	05/04/01	Bad quality	Bad quality

2.3.5 Results of the triad

The Dutch and Flemish triads have been applied on the results of the field tests. The conclusions of the triads are given below.

In the Dutch triad methodology, the data can lead to three conclusions:

- = Not or little contaminated (chemically) / no to little effect (biologically)
- ± = Moderately contaminated (chemically) / moderate effects (biologically)
- + = Severely contaminated (chemically) / severe effects (biologically)

Table 2.4: Results of the Dutch triad

	Chemical	Ecotoxicological	Biological	Conclusion
Mortagne 6/1/00	±	+	±	+
Bossuit 8/11/00	+	+	±	+
Lixhe 10/11/00	+	+	±	+
Mortagne 2/4/01	±	±	±	±
Bossuit 3/4/01	+	+	±	+
Lixhe 4/4/01	+	±	-	+
Grembergen 5/4/01	±	-	-	±

In the Flemish methodology, the data can result in four quality classes:

- 1 good quality
- 2 moderate quality
- 3 poor quality
- 4 very poor quality

Table 2.5: Results of the Flemish triad

	Chemical	Ecotoxicological	Biological	Conclusion
Mortagne 6/1/00	4	4	4	4
Bossuit 8/11/00	4	4	3	4
Lixhe 10/11/00	4	4	4	4
Mortagne 2/4/01	4	2	1	3
Bossuit 3/4/01	4	4	3	4
Lixhe 4/4/01	4	4	4	4
Grembergen 5/4/01	3	1	3	3

The triads give comparable results, with a poor quality or moderate effects in Grembergen and in the sample from the second campaign in Mortagne, and a very poor quality or severe effects in all other locations.

2.4 Case studies

In five case studies issues were investigated that occurred during the project (see annexe 4 for more details).

First, a comparison was made between the biological assessment methods in Belgium, Flanders, France and the Netherlands. The indices are compared in a survey of four locations in the rivers Meuse and Scheldt. Three of the locations were sampled twice. All seven sediments showed high levels of pollutants. A combination of the Biotic Sediment Index (BSI) and the determination of the oligochaete community seems to be a promising method (see also 2.3.4). Mentum deformities of Chironomidae (midges) turn out not to be suitable for the monitoring of the sites since the density of the Chironomidae was too low and were even absent at most sampling sites.

In the next study a methodology is described that can help managers take clear and objective decisions with regards to what chemicals have to be prioritised during risk assessment of sediments.

The third case study compares specific and non-specific methodologies for the analysis of chlorinated phenols.

The fourth study also focused on issues during analysis, namely on the extraction methods for the determination of heavy metals and of phosphorus in sediments.

Finally, the fifth study evaluated the applicability of transplanted zebra mussels (*Dreissena polymorpha*) for the assessment of contaminated Flemish rivers. At 30 Flemish watercourses, caged zebra mussels, originating from a drinking water basin were exposed for 4 weeks. At 8 sites all mussels died and at some other sites mortality was rather high. In some cases, (4 sites) this was probably due to accumulation of sediment in the cages. At the others sites mortality was high despite the fact that no accumulation of sediments occurred. At those sites, mortality can be ascribed to the significantly high load of pollutants.

2.5 Conclusions and recommendations

Chemical analyses and bioassays should be carried out using material that is identically sampled and at the same time as the macro-invertebrates are sampled (integrated sampling). An integrated sample for all three components is possible, but it is not clear whether this will limit the determination level of the macro invertebrates due to damaged setae etc.

The LIFE-project reached an agreement on the parameters, but it is not yet clear whether all analytical procedures used are similar. Therefore, it is recommended to use European standardised procedures.

An intensive survey of the sediments in the river basins of the Scheldt and Meuse can reduce the number of chemical parameters that have to be analysed because some chemicals, like DDT, are not used anymore. So, if they are currently not present in the sediments, it is most likely that they will not be found in the future. This decision must be made in close cooperation with chemical specialists and policy makers.

The biotic indices are a good tool for the interpretation of the biological data, but they are not yet proven internationally. Therefore, it seems to be interesting to evaluate several indices on a large data set, which contains data about species and densities.

The chemical analyses are focussing on total concentrations of the contaminant. However, the trend is to focus more on the bio-available fraction. The non-bio-available fraction does not form a risk for the environment and therefore ecological restoration might not always be necessary. Other extraction procedures have to be introduced. The tenax-extraction method seems to be promising for the extraction of the bio-available fraction of PAH's and PCB's. EDTA is suggested for the extraction of the bio-available fraction of heavy metals. On the other hand, more information of the bio-available fraction at a location can probably be gathered by the measurement of AVS-SEM and/or the measurement of the concentration of the contaminants in the interstitial water. These methodologies deserve much more attention because they improve the risk assessment and might reduce the costs for restoration and remediation.

Overall, a better understanding of the possible effects in relation to the presence of a mixture of contaminants is necessary to improve the decision process. Toxic compound Identification Evaluation (TIE) is a promising tool for this and has to be included in the triad assessment approach.

In the assessment methodology, there is no measurement included for the amount of sediment at the sampling location. It might be worthwhile to find a rapid method in order to have a rough idea of the amount of (contaminated) sediment at a site. Included in monitoring this can also give valuable information about the sediment transport processes within the river system.

There seems to be a lack of good reference data. The development of good reference data has to be done at an international level. This must be combined with the development of international sediment quality criteria.

Most sediment-sampling programs are focussed on the sediment itself. It might be interesting to have an idea of the contamination bounded to particles in suspension. In France, the suspended solids are sampled for that aim. In Flanders, the FEA measures the quantity but not the quality of suspended solids, at a non-regular base. It has to be considered whether this is a part of the water quality or the sediment quality assessment.

3 Prospects for solutions

3.1 Data base on dredging and treatment of sediments

Once there is insight in the quality and possible risks of the sediment, it is time to think about solutions. In the LIFE-project, a database was built with information on dredging, on destinations for dredged materials, on methods for treatment, and related subjects. The database is accessible from Cdrom (attached to this report). Via the opening sheet, one can zoom in on specific subjects.

For example, the theme sheet leads to the choice of the disposal circuit. After general information, it is possible to zoom in further to the concrete technique. If known, costs are presented (in €).

Figure 3.1: Screen with general information

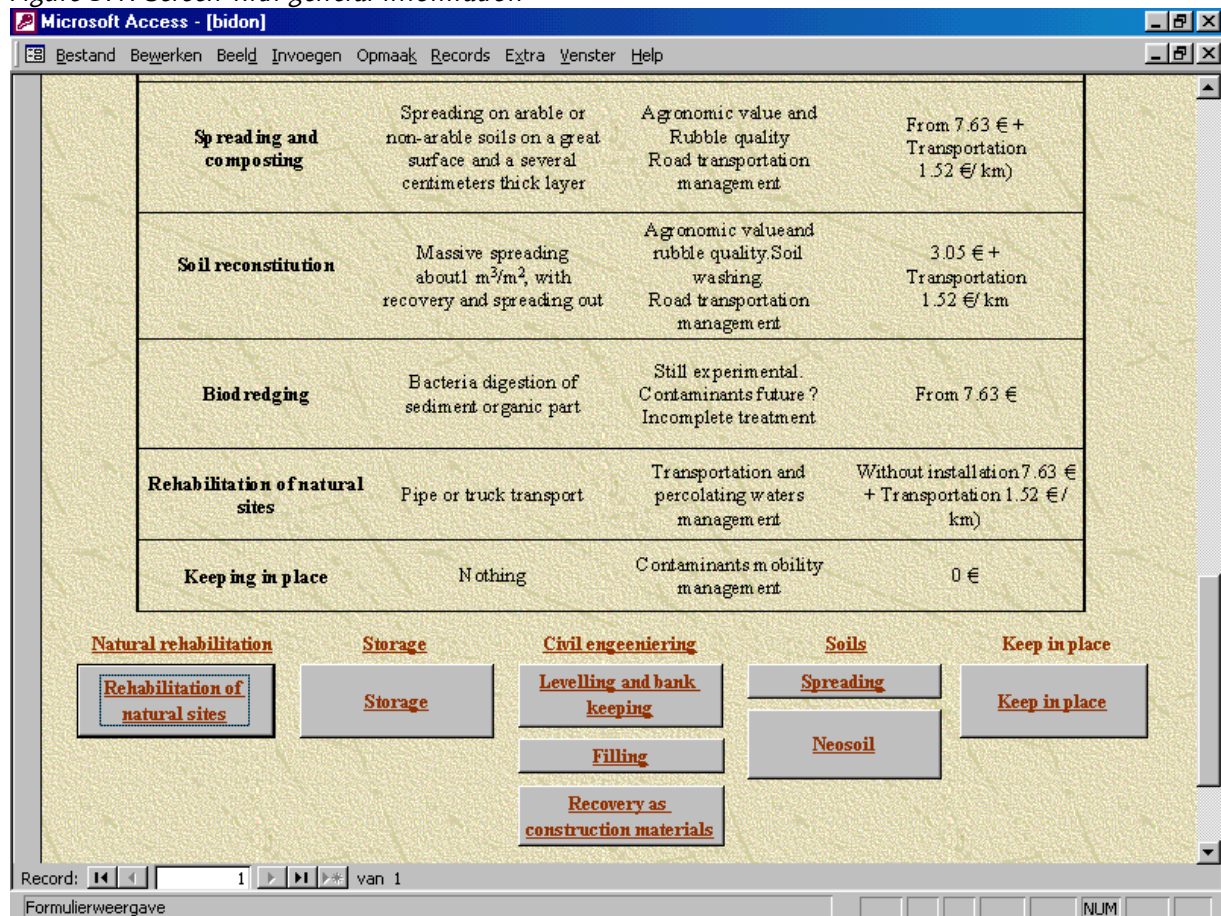
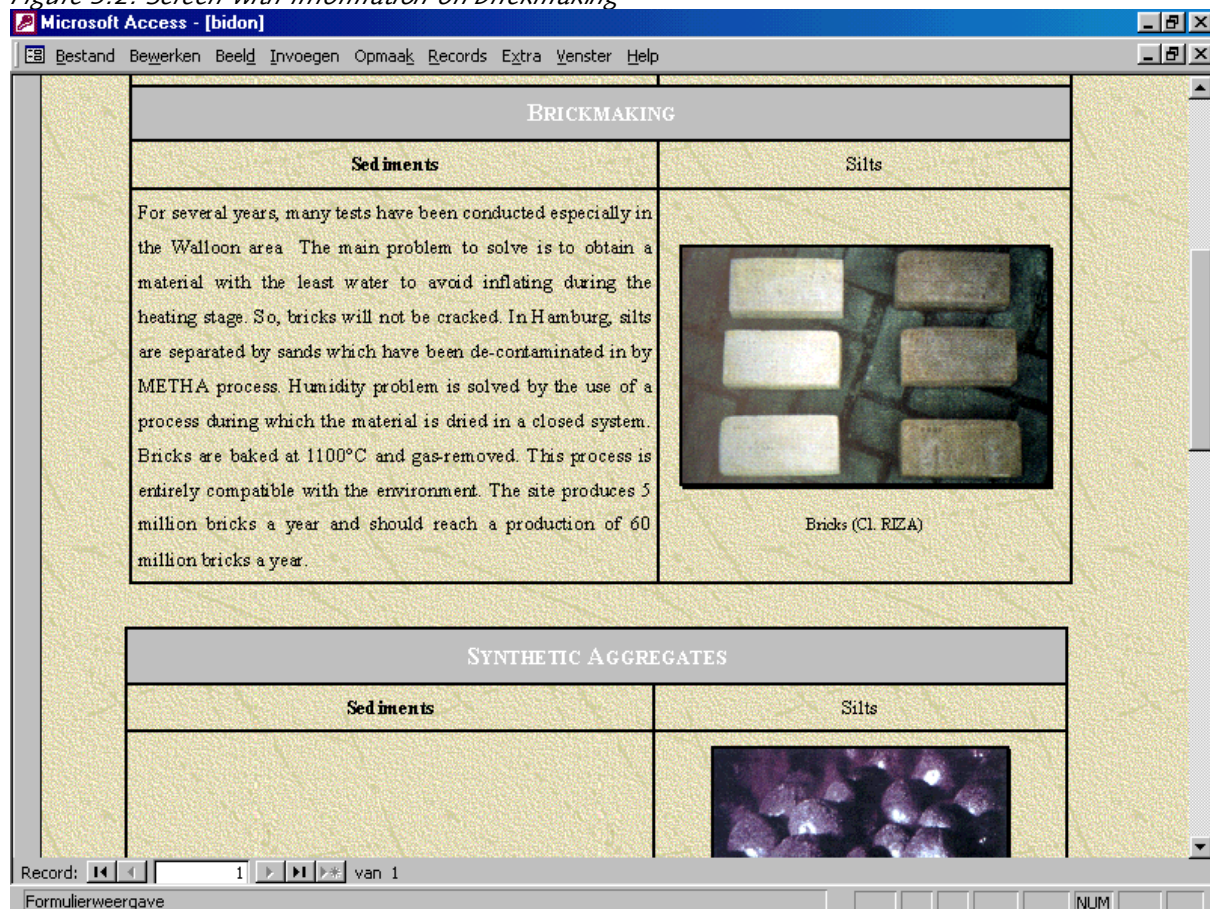


Figure 3.2: Screen with information on brickmaking



The theme sheets are divided in five sections:

1. Characterisation: definition of sediments, main contaminants, presentation of cubage, sampling and analysis methods.
2. Environmental evaluation: impact studies, risk analysis, live cycle analysis.
3. Destinations: spreading, neosoil and soil amelioration, natural area rehabilitation, levelling and bank keeping, embankment, building materials, stay in place, disposal.
4. Extraction technologies: survey, extraction (common mechanical dredges, common hydraulic dredges, pneumatic dredges, specifically developed dredges and tools for dredging with important environmental risk), and transportation. For each of these sections, a general presentation is associated as well as the general advantages and inconveniences of each technique. There is also a link to the descriptive technical sheet of each dredge composed by a descriptive text of the dredge (functioning principle) as well as a common recapitulative table to all the technical sheets:
 - Types of dredged materials;
 - Type of works; environment, maintenance, ditch, river;
 - Depth of work;
 - Capacity of the tool;
 - Precision;
 - Yield in m³/hour;
 - Costs;
 - Associated transport mode;
 - Qualitative evaluation of the 're-putting' (weak, medium, important);
 - Average water content;
 - Advantages and inconveniences.
5. Treatment: pre-treatment (separation), treatment;

This part deals in a first time with the definition of the pre-treatment concept (dehydration or granular separation) and the treatment concept (physicochemical, immobilisation and thermal treatment, biological treatment). Different techniques in situ and ex situ are presented on technical sheets constituted by a

descriptive text (functioning principle, preparation of sediment, application field...) and by a common table to all sheets (type of treated pollutants, entry products, output products, advantages and process limits).

3.2 Decision support system

3.2.1 DSS lay-out

A decision support system (DSS) is added to the database. The DSS is intended for administrative services in charge of dredging operations management and technical services and research agencies in charge of bringing help to administrative and industrial services in establishing the basic elements necessary for decision-making. The DSS is a tool to guide the operator towards concrete solutions, from dredging until the sediment ultimate utilization.

The DSS works along two major steps:

1. Entry of primary parameters to identify the project, characterize the sediment, the waterway and the waterway's uses, leading first to conclusions with regard to the extraction mode;
2. Entry of complementary parameters according to the circuit, leading to conclusions with regard to the extraction and transportation modes and each circuit technical, environmental and financial feasibility.

The techniques and methods suggested in the DSS were selected according to:

- Costs;
- Environmental impact;
- Technical feasibility;
- Applicability considering the sediment characteristics;
- Applicability considering the level of technical development of the technique.

After passing through the DSS, recommendations are given on the method of dredging, the way of transportation and the final destination of the specific sediment. Also the costs are given (see figure 3.3 below).

Figure 3.3: Recommendations from the DSS

Destination	Pre-Treatment	Composting	Immobilization	Extraction	Transport	Recommended	Conceivable	Unrecommended	Cost (€)
Keep in place									0
Keep in place + biologic Treatment									260 750
Keep in place + Consolidation/Stabilization in situ									651 875
Keep in place + containment									621 500
American dredging									391 125
Jetsed									521 500
Levelling				Usual mechanical dredgers					1 050 000
Forestation				Usual hydraulical dredgers					1 400 000
Terraces and harbour works	no	no		Usual mechanical dredgers	Barge				1 468 600
Waste lands and industrial sites	no	no		Usual mechanical dredgers	Barge				1 390 375
quarries, mines, CET II and III rehabilitation	no	no		Usual mechanical dredgers	Barge				1 468 600
Road TP	no	no		Usual mechanical dredgers	Barge				1 468 600
Urbanization	no	no		Usual mechanical dredgers	Barge				1 416 450
Neosoils	no	no		Usual mechanical dredgers	Barge				1 364 300
Natural site	no	no		Usual mechanical dredgers	Barge				1 364 300
Traditional spreading	yes	no		Usual mechanical dredgers	Barge				2 041 988
Agricultural spreading	yes	no		Usual mechanical dredgers	Barge				2 056 863
CET II	no	yes	no	Usual mechanical dredgers	Truck				3 972 500
Water storage	no	yes	no	Usual mechanical dredgers	Truck				2 799 125
Ground storage	no	yes	no	Usual mechanical dredgers	Truck				2 929 500
Incineration	yes			Usual mechanical dredgers	Pipe				2 704 800
Thermal desorption	yes			Usual mechanical dredgers	Pipe				2 779 175
Wet oxidation	yes			Usual mechanical dredgers	Pipe				2 779 175
Vitrification	yes			Usual mechanical dredgers	Pipe				2 853 650

3.2.2 DSS results for three testing locations

The DSS was tested on the data of the locations Mortagne, Bossuit (both Scheldt) and Lixhe (Meuse). For these locations, the sampling and analysis were complete, and the entire layer was sampled, which is preferable when assessing management scenarios.

In the first step, the DSS first gives preliminary conclusions on the risk of the sediment:

Table 3.1: Preliminary conclusions

	Mortagne	Bossuit	Lixhe
Type of contamination	Heavy metal contamination		
Danger mark	2	3	3
Sensitivity	3	3	3
Dispersion mark	1	3	3

The danger mark gives insight in environmental risks in general. In this case, Mortagne is less contaminated than the other locations. The sensitivity gives insight in the environmental circumstances in a broad sense at the location (i.e. urbanisation degree, fauna, flora present). The dispersion mark represents the contaminant diffusion during operating the sediment. In this case, the water agency Artois-Picardie, who performed the calculations, had more information on the flow characteristics of the site.

After these preliminary conclusions, in the second step, the software asks for more data and gives recommendations on the destination of the sediment. In this case, the programme recommends as follows:

Table 3.2: Recommendations for three testing locations

		Mortagne	Bossuit	Lixhe
Embankment	Pre treatment	Yes	Yes	Yes
	Treatment	Yes	No	No
	Dredging mode	Environmental dredges and tools	Environmental dredges and tools	Environmental dredges and tools
	Final destination	3 km on the bank	3 km on the bank	3 km on the bank
Spreading	Transport mode	Pipe	Pipe	Pipe
	Pre treatment	Yes	Yes	Yes
	Treatment	No	No	No
	Dredging mode	Environmental dredges and tools	Environmental dredges and tools	Environmental dredges and tools
Storage	Final destination	3 km on the bank	3 km on the bank	3 km on the bank
	Transport mode	Pipe	Pipe	Pipe
	Pre treatment	Yes	Yes	Yes
	Treatment	No composting or immobilization	Immobilization	Immobilization
Thermal treatment	Dredging mode	Environmental dredges and tools	Environmental dredges and tools	Environmental dredges and tools
	Final destination	3 km far away the river	3 km far away the river	3 km far away the river
	Transport mode	Truck	Truck	Truck

The software needs to be further developed; i.e. there is a problem with the term 'spreading'. Paradoxically, 'traditional spreading' is not recommended, but 'agricultural spreading' is conceivable. In the cost calculations, spreading is not taken into account.

For Mortagne (as an example), this leads to the following results:

Table 3.3: Costs for solutions at Mortagne

Mortagne	Global average cost	m ³ average cost
Embankment	2 300 000 €	85 €/m ³
Storage	1 600 000 €	60 €/m ³
Thermal treatment	2 700 000 €	100 €/m ³

For each kind of destination, the cost results are not very different from the average costs and the average costs seem to be representative for reality.

There is no substantial difference between the recommendations for the three sites; the problems along the Scheldt are globally similar. Some destinations are not recommended: keep in place and levelling solutions (regarding pollution and volume), re-suspending solutions (American dredging and jet regarding water flow), and spreading solutions (regarding pollution). Embankment solutions (terraces and harbour works, wastelands and industrial sites) are conceivable. The recommended solutions are to store or to treat the sediments. Comparing the costs, the best solutions seem to be:

- Mortagne: water storage or ground storage;
- Bossuit: inertage or vitrification;
- Lixhe: vitrification.

3.3 Conclusions and recommendations

The database gives a broad overview of the actual international knowledge on dredging and handling contaminated sediment. The French department on waterways ('Voies Navigables') has already worked with the database, and has come to the conclusion that the cost estimations are rough. This is probably caused by the very few real treatment experiences.

It is recommended that the information be made broadly accessible, i.e. via the Internet.

Globally, the recommendations given by the DSS seem to be close to reality. A remark can be made that the locations tested that were very similar (big river, polluted sediments and a low average current). Therefore, the recommendations do not differ much for the three sites.

The software contained very few bugs, when working with it. The ergonomic aspects of the programme however, must be smoothed out.

The DSS is, at this stage, still fragile and needs to be practiced and improved. It is recommended to test the DSS on locations that have a bigger divergence in quality.

4 Legal aspects

One of the questions when drafting a common river basin management programme is whether proposed measures would fit in the different national regulatory and legal systems. In order to explore opportunities and impossibilities, the LIFE-project made an inventory of relevant policies, laws and regulations. During the making of the inventory, it soon appeared that in all four countries/regions paper portrayed a world that was different from practice. Therefore, the project team decided to make an assessment of the divergent and convergent trends in the practices of applying those regulatory frameworks.

4.1 *Divergent and convergent trends in regulatory systems*

The manner, in which the institutional aspects of the four regulatory frameworks have taken shape, also depends on the constitutional and administrative legal framework that governs the manner in which the public sector is organized in each of the four countries/regions. The most salient point in this perspective is that in Belgium the federal government and the Regions, among which Flanders and Wallonia, and the Communities share central government powers. In the case of contaminated sediment, and river management more in general, the Regions are the competent entities. This is also the reason why Flanders and Wallonia are partners in this project, instead of Belgium, as such.

The inventory made in the LIFE-project of the regulatory systems showed that full harmonization of statutory instruments would require a major legislative effort. However, harmonization of statutory instruments, is only feasible after a shared understanding of the problem has been developed and if common policy objectives and shared means of attaining those objectives have been identified. In the LIFE-project, steps in that direction are presented (see chapters 2 and 3), while the EC Water Framework Directive presents an important trigger for that process. In this perspective it becomes relevant to assess how significant the differences identified are in practice and whether divergent and convergent trends can be identified if this practice is taken into account. These trends, especially the convergent ones, may provide a basis for identifying fruitful elements for further cooperation.

The following provides a thematic analysis of divergent and convergent trends in the practice of dealing with contaminated sediments in the four countries/regions. It provides a basis for identifying trends that may be used to further cooperation among the four countries/regions.

4.1.1 **Legal basis for dealing with contaminated sediment**

Flanders and the Netherlands deal with contaminated sediment on the basis of specific regulations designed to deal with contaminated soil and which perceive contaminated sediment in situ as an environmental problem. France and Wallonia do not have such a regulatory system. This is the most significant difference, to which most other differences in the regulatory systems can be related. It leads in practice to the divergent trend that in Flanders and the Netherlands dredging takes place for ecological reasons, while that is not the case in France and Wallonia. It is important not to lose sight of this underlying difference in the regulatory systems. It is after all the underlying philosophy of the regulatory framework that influences how policy priorities are set and thus to what activities financial resources are directed.

Participants from all four countries/regions, however, agreed that contaminated sediment is perceived as an environmental problem, also for ecological systems in the river environment. The convergent trend, thus, is that, although not reflected in the regulatory frameworks of each of the four countries/regions, contaminated sediment is perceived as an environmental problem, albeit to different degrees.

4.1.2 **Monitoring for contaminated sediment**

Related to the previous point and a divergent trend, Flanders and the Netherlands engage in monitoring for contaminated sediment, while France and Wallonia do not (also see 4.2.5). The methods used by Flanders and the Netherlands to classify sediment, differ.

4.1.3 **Reasons for engaging in dredging of contaminated sediment**

Likewise in Flanders and the Netherlands, and not in the other two countries/regions, regulations determine that dredging activities may take place and may, given certain circumstances, be prescribed by

the competent authorities for ecological reasons. In all four countries/regions dredging in addition, may take place for river management and navigational reasons. Another important difference is that in Flanders and the Netherlands the system for dealing with contaminated sediment is based on laws and regulations concerning soil treatment, instead of laws and regulations dealing with river maintenance and dredging activities that are engaged in for that purpose. This implies that in Flanders and the Netherlands contaminated sediment in situ is explicitly regarded as an environmental problem for the ecology of the river, while in France and Wallonia the environmental problem presented by contaminated sediment has not been translated into the regulatory framework. Therefore, it is a significant divergent trend.

In all four countries/regions, dredging can be engaged in for purposes of maintenance reasons and for protecting economic interests, such as navigation and tourism. Moreover, in Flanders and the Netherlands both navigational and maintenance reasons are important factors in determining whether a dredging operation is actually carried out or not. Thus, the convergent trend is that in all four countries/regions navigational and maintenance reasons are important elements in determining whether to engage in dredging or not.

4.1.4 Classification of waterways

The Netherlands does not use a system that classifies rivers into navigable and non-navigable rivers, while the other three countries/regions use such a system to determine the institutional framework for river management. However, in all four countries/regions similar reasons play a role in determining the institutional framework for river management. Therefore, the following convergent trends can be identified:

- In all four countries/regions a higher level, central government, body responsible for environmental (water) management is involved in determining policies for contaminated sediment.
- In all four countries/regions higher level, central, government bodies, such as ministries, or agencies or directorates of those ministries, are responsible for river management and implementing policies regarding contaminated sediment in larger, mostly navigable, rivers.
- In all four countries/regions, bodies responsible for navigational issues are involved.
- In all four countries/regions lower level, decentralized, government bodies, such as provinces and municipalities are responsible for river management and implementing policies regarding contaminated sediment in smaller, often non-navigable, rivers.

4.1.5 Nature of standards used to classify sediment/dredged material

This point, again, is related to the legal basis for dealing with contaminated sediment (4.2.1). Both Flanders and the Netherlands use methods to classify sediment while located in the river environment and with a view to determining the risks presented to the ecology of a river, France and Wallonia do not. Flanders and Wallonia classify dredged material according to possible harm to the receiving environment, with France using an unofficial system. In Flanders and the Netherlands, however, possible harm to the receiving environment also plays a role in the classification system used. The divergent trend thus is that in two countries/regions the receiving environment does not play a role in the classification of contaminated sediment, the convergent trend is that the receiving environment is an important factor in the classification of dredged material in all four countries/regions.

4.1.6 Classification of the dredged material as waste

With the exception of France, until late spring 2001, the countries/regions classify dredged materials as waste. However, the other three countries/regions have in place exceptions or declassification procedures that enable the sediment, if not or lightly contaminated, to be used on soil, just as in France. The qualification of dredged material as waste in all four countries/regions is found to be problematic for developing sustainable solutions for dealing with (contaminated) sediment. The convergent trend, therefore, is that the qualification of dredged material as waste is found to be problematic and that all countries/regions have procedures for facilitating the re-use of not or lightly contaminated sediment.

4.1.7 Disposal and destination of contaminated dredged material

In France, a policy for the re-use of contaminated sediment, after treatment, is not yet in place, while in the other three countries/regions it is. In Flanders and the Netherlands, however, treatment and re-use of contaminated sediment is only applied to a small portion of contaminated sediment. In all four countries/regions the most contaminated dredged materials are, or are to be, disposed of in depots. This is

the case even though public opinion in all four countries/regions regards recycling as a more sustainable solution than the use of depots, despite the lower costs of depots. In all four countries/regions least contaminated sediment and not contaminated sediment is used on land. The convergent trend is that in all four countries/regions depots play an important role in dealing with contaminated sediment, re-use policies in practice playing a minor role, and that for non-contaminated or lightly contaminated sediment re-use on land is allowed.

4.1.8 Actors involved

The nature of the public actors, ministries and other public authorities, is not identical, with their precise competencies often varying between the four countries/regions. In addition, in France, and not in the other three countries/regions, private owners of the riverbed are involved in the policy process. Nevertheless, in all countries/regions a host of actors – public and private – are involved in the policy process, which results in a complex decision making process. A convergent trend is that in all four countries/regions the following types of actors are involved in policies regarding contaminated sediment:

- Political actors, including several ministers;
- Public sector actors varying from those involved in navigation and water management to those involved in the protection of the environment and varying from central government bodies to intermediate and local government bodies;
- Industry varying from the shipping industry and polluting sectors to those engaged in dredging and disposing or treatment and re-use of dredged material; and
- Civil society in the form of NGO's and private citizens and their organizations, especially as a result of environmental impact and other procedures that apply in all four countries/regions to various stages of the decision making process applicable to contaminated sediment.

4.1.9 Common concerns

A somewhat different aspect that may be regarded as a convergent trend is represented by the common concerns that the authorities responsible for dealing with contaminated sediment face. The most salient problems that arose during the course of the project are as follows.

- The lack of sufficient financial resources to deal with contaminated sediment and the resulting dredged material.

One common element, which emerges from the analysis in its totality, is that the problems manifest themselves most clearly with respect to historic sediment pollution. This means that applying the polluter pays principle in individual cases is difficult, if not impossible, because of difficulties in identifying the polluter and/or statutory limitation terms. This, in turn, implies that funding for dealing with contaminated sediment to a large degree has to come from public funds. Stimulating cleaning and re-use of dredged material may of course create an incentive for the private sector to develop re-use options. However, in that case a further issue presented itself: the companies involved will require a guarantee of access to sufficient dredged material of the appropriate quality. Such a guarantee would need to be a component of an integrated policy for dealing with contaminated sediment, if the private sector is to be more closely involved in developing re-use options. A similar argument applies, if private sector investment in depots for contaminated sediment is found to be desirable.

- The NIMBY syndrome¹ has emerged in all four countries/regions when it comes to finding locations for depots and to identifying sustainable re-use options. This is the case also in Wallonia now that dredging is to recommence and that locations are sought for the resulting materials.

In this respect, it is of interest to note that participants agreed that the public perception of dredged materials is very limited informed, often showing similarities to the public perception of radioactive material. Furthermore, it was pointed out that a project in Germany on re-using treated sediment in building blocks has not been very successful – the blocks apparently are not perceived as a desirable commodity, i.e. they are difficult to market.

4.2 Conclusions and recommendations

A common knowledge base of divergent and convergent trends is important both because it offers a basis for further cooperation and because it provides a more thorough understanding of why the negotiating positions of the participating countries/regions differ. It is in this sense that the divergent trends can be of aid in identifying topics that might be less fruitful as a focus for seeking cooperation. Those

¹ Not In My Back Yard

issues that confront each of the four countries/regions with similar practical problems as well as those issues identified as common concerns, probably offer the most fruitful elements for further cooperation, through a step-by-step approach. The differences in the regulatory frameworks, while not to be forgotten, are probably best addressed on the mid-term within the framework of the implementation of the EC Water Framework Directive. That being said, it was also concluded during the project that the EC Water Framework Directive only indirectly pays attention to the problem of contaminated sediments. It deserves consideration to give sediments a more prominent place in the Water Framework Directive or in its implementation process.

A number of differences found in the regulatory systems of the four countries/regions do not need to be streamlined because they are not material to the problem at stake. A point in this respect is the divergent classification systems for rivers (navigable – non-navigable) used in the different countries/regions and the division of competencies among government bodies that follows from this system in the countries/regions (4.1.4). Similarly, the types of actors involved do not merit further consideration (4.1.8).

An issue that does merit further attention is the nature of the standards used to monitor and classify sediment (4.1.2 and 4.1.5). While this is undeniably a difference in the regulatory framework of the four countries/regions that results in divergent trends in practice, it also is a topic that, in first instance, can be addressed through cooperation at the technical and scientific level (chapter 2 reports on the first steps in cooperation on this topic). The results of further work can be used to define, for the river basins in question, the objective of 'good ecological status' and to prepare an inventory of the status of the sediment, and thus would provide a basis for implementing the EC Water Framework Directive. It is, furthermore, important that this topic be addressed on the short term because, ultimately, it will provide the basis for developing a common philosophy for dealing with contaminated sediment.

The common problems encountered as a result of the fact that European Community regulations prescribe that dredged materials be classified as waste does merit further consideration, especially with a view to enabling the development of sustainable re-use options for (contaminated) sediment. This issue could be addressed through cooperation within the EC Water Framework Directive, also with states facing the same problem in other river basins. Eventually, it would require amendment of the EC Waste Framework Directive².

One key to successfully addressing the contaminated sediment problem is finding sustainable destinations for the dredged materials, be it in re-used form, after treatment, or in depots (4.1.7). Both technical and socio-economic aspects present common problems (see also chapter 3). The socio-economic aspects have not been addressed in the LIFE-Project, but two such aspects, in the form of common concerns, did emerge during the discussions (4.1.9). It is worth exploring common strategies to address these common concerns – the role of the private sector in finding and financing solutions and the NIMBY syndrome. Pilot projects, including trans-boundary projects involving two or more countries/regions that address both the technical and the socio-economic aspects could be designed in order to find sustainable destinations for dredged materials.

Another issue that merits further attention is how the regulatory frameworks of the four countries/regions can be made to accord with the river basin management approach contained in the EC Water Framework Directive. One topic that requires consideration, on the short term, is the relationship between upstream and downstream locations. This implies that policies for contaminated sediment and dredging for those sediments in upstream locations would have to take into account the effects on downstream locations, including downstream locations in another country/region. Where polluting emissions exist, these should be addressed with priority with a view to also minimizing further contamination of sediment. In addition, in relation to the rate at which emissions are addressed, the moment at which it is useful to start addressing the issue of contaminated sediment needs to be identified. Moreover, the question of the allocation of financial resources within the river basin management approach merits attention. Should such resources be allocated on a country-by-country basis or on the basis of the river basin as a whole? This is a sensitive issue as it raises considerations with respect to the polluter pays principle. While these considerations are not unimportant, they should not bar the development of

² Directive 1975/442/EEC, 15 July 1975, OJ 1975 L 194/47 amended by Directive 1991/156/EEC, 18 March 1991, OJ 1991 L 78/32.

sustainable river basin management in a trans-boundary context. This is especially the case if, also in terms of the benefits for the downstream state, an euro spent upstream may be more efficiently spent than the same euro spent downstream.

The above identifies elements that can be taken-up within the framework of the ICPM and ICPS in order to address the problems presented by contaminated sediment and the implementation of the EC Water Framework Directive. The elements concern, in particular:

- Development of a common monitoring system and common standards for classifying sediment, in continuation of the LIFE-Project,
- Implementation of the EC Water Framework Directive and, in particular, on the short term, the relationship between upstream and downstream locations and, on the mid-term, the issue of the different philosophies that are at the basis of the regulatory systems for contaminated sediment and the allocation of financial resources,
- Common problem encountered in finding sustainable solutions to the re-use of dredged material, due to their classification as waste,
- Finding sustainable solutions to the re-use or deposition of (contaminated) dredged materials through trans-boundary pilot projects. In this framework it can be useful to also address
 - involvement of the private sector, and
 - public perception of dredged material.

Given the tasks ahead, it would be useful if the ICPM and the ICPS each would establish a permanent expert group to consider issues related to contaminated sediment. These groups, within the overall framework of the ICPS and ICPM, would provide a sustainable institutional basis for the necessary work on contaminated sediment to proceed as well as a basis for continuing the work initiated through the LIFE-Project. The latter could include the development of river specific actions on contaminated sediment for inclusion in the Action Programs for the Meuse and Scheldt, respectively MAP2 and SAP2.

5 Overall conclusions

In the LIFE-project on contaminated sediments, the first steps were taken to tune the management of contaminated sediments in an integrated technical and administrative-judicial manner.

Common method

A common method for sampling and analysing sediment was developed and tested on four locations in the Scheldt and Meuse basins (chapter 2). The common method gives recommendations for the methods of sampling sediment, and for the parameters to analyse in the samples. The assessment of sediment depends on the final objective; for purposes of monitoring the ecological quality, a triad approach with physico-chemical, ecotoxicological and biological assessment is the most appropriate. For maintenance purposes, physico-chemical assessment, combined with specific bioassays will satisfy.

The sampling also differs according to the reason for the assessment. In the case of monitoring ecological quality, a grab sampler – sampling the top layer – is the appropriate method. In the case of managerial reasons, a core sampler – giving insight in the whole layer of the sediment – is more useful.

There is broad agreement among the participants on the parameters for physico-chemical analysis. A small list of parameters requires further discussion and research.

The choice for the tests within the ecotoxicological assessment and for the biological classification system could not yet be made based on the limited dataset of the project. The sites on which several tests have been performed for evaluation had the same (bad) quality, which made it impossible to make a good evaluation. However, a team of specialists agreed upon a proposal for both the ecotoxicological as well as the biological assessment method. It was agreed that for the ecotoxicological assessment, a battery of similar tests is preferable. This battery should include tests for acute toxicity of pore water, for chronic toxicity of pore water and sediment contact tests. In the case of the biological classification, the use of whole community is advised, so several indexes can be used for interpretation. In order to put up reliable common standards, more data is needed.

Field tests

Three sites were tested twice during the project (Mortagne, Bossuit (both Scheldt) and Lixhe (Meuse)). According to the results of the triad-approach, the sites were polluted and even toxic, varying from moderately (Mortagne) to severely toxic (Bossuit and Lixhe). The site added during the second measuring campaign in order to make a comparison with a less polluted spot (Grembergen), was less polluted indeed, but still showed moderate effects on the testing organisms and was classified as 'poor quality'.

Possible solutions

In order to identify possible solutions, a database was formed with international information on dredging, treatment and disposal of contaminated sediment. Added to this database was a decision support system to help make choices in the different techniques. The DSS applied on the results of the three sites mentioned above, recommended to store, embank or treat the sediment thermally.

Legal and regulatory aspects

The regulatory systems of, on the one hand, Flanders and the Netherlands and, on the other hand, France and Wallonia present significant differences when it comes to their approaches to contaminated sediment. In Flanders and the Netherlands on the basis of statutory provisions, contaminated sediment in situ is regarded as an environmental problem for the riverine ecosystem. In France and Wallonia, this is not the case, while the focus lies on the receiving environment (ex situ). Most other differences in the regulatory frameworks can be attributed to this basic difference in philosophy. In practice the differences, however, are somewhat less pronounced, and convergent trends can be identified.

A common knowledge base of divergent and convergent trends is important both because it offers a basis for further cooperation and because it provides a more thorough understanding of why the negotiating positions of the participating countries/regions differ. The divergent trends can be of aid in identifying topics that might be less fruitful as a focus for seeking cooperation, either because they are likely to increase discord among participants or because a divergent trend in the regulatory system is in practice irrelevant for resolving the issue. Those issues that confront each of the four countries/regions with

similar practical problems as well as those issues identified as common concerns, probably offer the most fruitful elements for further cooperation through a step-by-step approach.

An issue that merits further attention, and that could be the first subject of the step-by-step approach, is the nature of the standards used to monitor and classify sediment. This is a topic that can be addressed through cooperation at the technical and scientific level. The participants on the LIFE-project also worked, very enthusiastically, at this level, and they were of the same opinion that the cooperation with the other participants was interesting and stimulating. It speaks for itself that it would be advantageous to prolong this cooperation.

The results of further work can be used to define, for the river basins in question, the objective of 'good ecological status' and to prepare an inventory of the status of the sediment. Thus, it would provide a basis for implementing the EC Water Framework Directive. Furthermore, it is important that this topic be addressed on the short term because, ultimately it will provide the basis for developing a common philosophy for dealing with contaminated sediment.

Another issue that deserves further notice is how the regulatory frameworks of the four countries/regions can be made to accord with the river basin management approach contained in the EC Water Framework Directive (though at the same time it was concluded that this directive itself could give sediments a more prominent place). One topic that requires consideration, in the short term, is the relationship between upstream and downstream locations. This implies that policies for contaminated sediment and dredging for those sediments in upstream locations would have to take into account the effects on downstream locations, including downstream locations in another country/region. Where polluting emissions exist, these should be addressed with priority with a view to also minimizing further contamination of sediment. In addition, in relation to the rate at which emissions are addressed, the moment at which it is useful to start addressing the issue of contaminated sediment needs to be identified. Moreover, the question of the allocation of financial resources within the river basin management approach merits attention. Should such resources be allocated on a country-by-country basis or on the basis of the river basin as a whole? This is a sensitive issue as it raises considerations with respect to the "polluter pays" principle. While these considerations are not irrelevant, they should not bar the development of sustainable river basin management in a trans-boundary context. This is especially the case if, also in terms of the benefits for the downstream state, an euro spent upstream may be more efficiently spent than the same euro spent downstream.

6 Recommendations

1. This report recommends, on the short term, to develop a common monitoring system and common standards for the classification of sediment in a step-by-step approach. The common monitoring system and the common standards can be used, among other things, to define the objective of 'good ecological status' in the Water Framework Directive and to prepare an inventory of the status of sediments in the Meuse and Scheldt basins. In the longer term, it might be recommendable to adjust regulatory frameworks, at which stage harmonizing those frameworks could also be considered.
2. Applying the common method on the Meuse and Scheldt basin could develop a common standard, because more types of sediments – also less polluted sediments – would be assessed. In this manner, an inventory of the status of the sediments in the basins is made in the same time. With a broader inventory, the Decision Support System can also be refined.
3. The inventory will be useful to select priorities in tackling the problem of contaminated sediment, and might give indications for emission reduction. In the more distant future, sediment transport models and erosion models could be added to the inventory, in order to make the priorities stand out in sharp relief within a river basin approach.
4. The development of a strategy, by the ICPM and ICPS, to address the problems presented by contaminated sediment during the elaboration of the second Action Plans for the Meuse and Scheldt. This strategy could also link the Water Framework Directive to sediment transport.
5. Within the course of implementing the EC Water Framework Directive, and in the development of the 2nd action programmes of the ICPM and ICPS, the following topics deserve consideration:
 - On the short term, the identification of sediment polluting parameters of concern, in order to identify the need for (additional) programs and measures for point and diffuse sources for these pollutants,
 - On the short term, to establish guidelines for dredging operations and the treatment/deposition of sediments originating from maintenance operations in waterways (main river, harbours, relevant tributaries and canals),
 - On the mid-term, to establish guidelines to deal with contaminated sediment that will facilitate attaining the objectives of the Water Framework Directive, including guidelines that address the (potential) danger presented by transport of contaminated sediments to ecological valuable areas in the river basin,
 - On the mid-term, the manner in which the basic philosophies underlying the regulatory systems of the four states/regions can be brought into closer harmony with each other, and
 - Economic and financial aspects of the river basin management approach, for example by adding sediment management and dredging operations as an item within the economic analysis of the River Basin Management Plans.
6. The establishment of expert-groups on sediment by the ICPM and by the ICPS to implement the recommendations 1 to 5. At this stage of development of general tools – like a common monitoring system – it could be advantageous for the ICPM and ICPS to combine forces.
7. It is recommended to the European Commission, to address the problems encountered in finding sustainable destinations for dredged materials that are related to the classification of dredged material as waste, with a view to developing a special management system for those materials, either as a special category under the EC Waste Directive or as an exception to that Directive. The European Commission is also recommended to strengthen the role of the EC Water Framework Directive in the management of sediment.
8. Finally, it is recommended to disseminate the findings of the project – among other ways – by Internet site, which in turn would be linked to an existing structure or organisation for ease of addressing maintenance queries (www.waterland.net/)

Annexes

1. Organisations and persons involved;
2. List of reports produced;
3. Selection of bioassays
4. Case studies worked out during the development of the common method
5. CDroms with the Database, DSS and Final reports from the themes (Theme 1: Legislation, Theme 2: Common Method, Theme 3: Field Testing, Theme 4: Solutions)

Annexe 1: Organisations and persons involved

Name	Organisation	Country/Region
Anciaux, André	MRW – DGRNE- OWD	Wallonia
Bakker, Tiede	Riza	The Netherlands
Bécart, David	VNF	France
Benschop, Pieter	Riza	The Netherlands
Bertrand, Marcel	Dir. Rég. Agric.	France
Beyen, Wouter	University of Antwerp	Flanders
Bogusz, Daniel	Agence de l'Eau Artois Picardie	France
Brujickere, Frans de	RWS Zeeland	The Netherlands
Cautaerts, Rudy	VMM	Flanders
Chuine, Gerard	Service de la Navigation Nord-Pas-de-Calais	France
Crélot, Isabelle	.E.A.Gx – MET LRH	Wallonia
De Bast, Benoît	MRW – DGRNE- DE	Wallonia
De Cooman, Ward	VMM	Flanders
De Deckere, Eric	U.I.A. Antwerpen	Flanders
Den Besten, Piet	Riza	The Netherlands
De Pauw, Niels	University of Ghent	Flanders
De Thysebaert, Didier	MRW – DGRNE- DE	Wallonia
Delcarte, Mr.	B.E.A.Gx	Wallonia
Derick, Marie	Région de Bruxelles-Capitale	Brussels Region
Detemmerman, Lieven	University of Ghent	Flanders
Detongre, Aubain	MRW – DGRNE- OWD	Wallonia
Dijk, Ricardo van	Riza	The Netherlands
Elswijk, Martijn van	Riza	The Netherlands
Florus, Marc	AMINAL	Flanders
Gabriels, Wim	University of Ghent	Flanders
Gosselin, Gérald	INCITEC	Wallonia
Groen, Klaas	Riza	The Netherlands
Grosdemange, Didier	In vivo	France
Hakstege, Pol	Ministerie Verkeer en Waterstaat	The Netherlands
Henneuse, Mrs. J.	INCITEC	Belgium
Heylen, Steven	University of Ghent	Flanders
Hiver, Jean-Michel	MET LRH	Wallonia
Julien, Bruno	European Commission	European Union
Kamps, Ria	RIZA	The Netherlands
Kerkum, Frans	RIZA	The Netherlands
Lesniak, Christophe	Agence de l'Eau Artois Picardie	France
Libert, Yves	MET LRH	Wallonia
Longchamp, Thomas	In vivo	France
Maesen, Philippe	B.E.A.Gx	Wallonia
Martin, Delphine	Agence de l'Eau Artois Picardie	France
Mergaert, Koen	AWZ	Flanders
Mulders, Ralph	Tauw b.v.	European Union
Neven, Cécile	MRW - DGRNE – DE	Wallonia
O'Shaughnessy, Janet	European Commission	European Union
Pijkeren, Dick van	Riza	The Netherlands
Postma, Jaap	Aquasense	The Netherlands
Prygiel, Jean	Agence de l'Eau Artois Picardie	France
Rienks, Hans	Riza	The Netherlands
Ringeling, Mr. R.	Ministerie Verkeer en Waterstaat	The Netherlands
Rooy, Marc de	Riza	The Netherlands
Six, Pierre	Chambre d'Agriculture du Nord	France
Tessier, David	VNF	France
Thomas, Christophe	DIREN	France
Tirez, Kristof	VITO	Flanders
Van De Guchte, Cees	Riza	The Netherlands

Van Der Wielen, Claire	ISSEP	Wallonia
Vandenbossche, Jean-Pierre	MRW – CRNFB	Wallonia
Vangheluwe, Marnix	EURAS bvba	Flanders
Vanwesenbeeck, Veerle	AMINAL	Flanders
Verdievel, Martien	VMM	Flanders
Verhaege, Hubert	Agence de l'Eau Artois Picardie	France
Verheij, Ellen	ICWS	The Netherlands
Vivant, Didier	Service de la Navigation du Nord-Pas-de-Calais	France
Weltens, Reinhilde	VITO	Flanders
Welter, Philippe	MET D421 Liège	Wallonia
Zundert, P. van	RWS Zuid-Holland	The Netherlands

Annexe 2: List of reports

Theme 1:

- Policy and legislation in the Netherlands, Flanders, Wallonia and France, Interim report of theme 1, November 2000
- Legal aspects and regulations for dealing with contaminated sediments, Final report of theme 1 of the LIFE-project on contaminated sediments, May 2001
- Legal aspects and regulations for dealing with contaminated sediments, Annexes to final report of theme 1 of the LIFE-project on contaminated sediments, May 2001

Theme 2:

- Interim report task 2, August 2001
- Methods for sediments quality assessment, Final report of task 2, December 2001
- de Deckere, E., W. Beyen, D Van Pelt, B. Veraart & P. Meire, 2001. Biological assessment of sediments: a comparison. Researchgroup Ecosystem Management, UIA, Antwerpen.
- Weltens, R., J. Provoost & C. Comelis, 2001. Methode voor: Prioriteitstelling en rangschikking van risicostoffen voor waterbodems. VITO, 2001/TOX/R/054, MOL.
- Van Deun, M., J. Deighton & G. Vanermen, 2001. Onderzoek naar bepalingmethoden voor gechlorreerde fenolen in sediment. VITO, Vito/MIM/R/091, MOL.
- Vanhoof, C., P. Van Bree & K. Tirez, 2001. Extraction methods for the evaluation of contaminated sediments. VITO, 2001/MIM/R/093, MOL.
- Bervoets L., R. Smolders, A. Covaci, C.S. Chu, D. Qadah, P. Schepens and R. Blust, 2001. The use of translocated zebra mussels (*Dreissena polymorpha*) for the assessment of polluted sediments in Flemish rivers. University of Antwerp.
- de Deckere, E., W. Beyen, D Van Pelt, B. Veraart, M. Florus & P. Meire, 2001. Biological assessment of sediments: a comparison. In: Pellei, M., A. Porta & R.E. Hinchee, 2002. Site characterization for contaminated sediments. Battelle Press, Geneve.

Theme 3:

- Field testing of a common methodology - First campaign, Report 1, November 2000
- Field testing of a common methodology - Second campaign, Report 2, October 2001

Theme 4:

- Detailed inventory of dredging methodology, treatment and possible uses of contaminated sediments, March 2001
- Polluted sediments management and re-use methodology (inventory and decision-making system on CD-rom), Februari 2002

Theme 5:

- Inception report/progress report 1, January 2000
- Progress report 2, July 2000
- Progress report 3, April 2001
- Technical interim report, December 2001
- Financial interim report, December 2001
- Progress report 4, December 2001

Annexe 3: Selection of bioassays

SELECTION OF SUITABLE TESTS

It is recommended to use a **battery** of tests.

The **criteria identified** for the selection of suitable tests in the present context are:

- representativeness for the sediment compartment
- robustness: reproducibility of the test; interferences/confounding factors are known
- sensitivity/ position in the spectrum of contaminants
- chronic versus acute: chronic shall be preferred to acute testing
- basic knowledge of the test, data on chemicals
- discriminative power: prioritisation is a good example for relevance of this parameter
- cost

These criteria will be relevant (++) highly relevant, + relevant, - less relevant) depending on the objective of the study. Four different objectives have been considered: local specific risk assessment, prioritisation, trend (in time), and risk of diffusion of pollutants.

For the selection of suitable tests, the objectives of the study should be first defined: see Table 1. Further investigation, including other tests and other endpoints (as for example biomarkers) may be necessary at a higher tier.

OBJECT	CRITERIA							CONCLUSION
	Representative of sediment	Robustness	Sensitivity	Chronic vs acute	Data on chemicals	Discriminative power	Cost	
(1) Local specific risk assessment	++	+	+	++	++	-	-	Sediment contact bioassays, for e. <i>Hyalella</i> , <i>Chironomus</i> , bioaccumulation test with <i>Tubifex</i> Taylor-made bioassays may be used.
(2) Prioritisation	+	++	++	+	+	++	++	Porewater bioassays may be used besides sediment tests; only well standardised bioassays
(3) Trend (in time)	-	++	+	-	+	+	+	Value of the historically chosen bioassay
(4) Risk for diffusion of chemicals	-	+	+	++	+	+	-	More directed to water quality; preference for the porewater/elutriate bioassay

TABLE 1: CRITERIA FOR THE CHOICE OF SUITABLE TESTS DEPENDING ON THE OBJECTIVES

Annexe 4: case studies worked out during the development of the common method

This annexe gives an overview of the case studies that have been during the development of the common method. A summary is given of the case studies and the reference of the report.

Biological assessment: a comparison

Biological assessment of sediments is an important methodology to see whether (contaminated) sediments form a risk for their natural environment. Different organisms are used for this: macro invertebrates, Oligochaetes, Chironomidae, Bivalves, nematodes. The composition of the macrobenthic community is used in many countries. The interpretation of the macrobenthic community can be done based on biotic indices. A specific index for the sediment was developed in Flanders, namely the Biotic Sediment Index (BSI), which is derived from the Belgian Biotic Index (BBI). The BSI is tested and evaluated in a large survey of the Flemish watercourses. Based on the 620 sampling locations the determination level of the different taxa to calculate the BSI was restricted. The assessment method based on mentum deformities of Chironomidae was also tested during this survey. This method is based on the percentage of deformities of the fourth larval stage of the Chironomidae. The deformities are a direct result of physical or chemical disturbance of the sediment.

The oligochaete community is used for sediment quality assessment in France. The Oligochaete Index of Sediment Bio indication (IOBS) is developed and combined with total density and percentage of Tubificidae without setae. Beside the macrobenthic species sediment assessment can also be based on the meiobenthic community, especially nematodes. This method is used in the Netherlands. Based on the life strategy of the nematodes the Maturity Index (MI) is calculated.

The four indices are compared in a survey of four locations, one on the river Meuse and three on the river Scheldt. Three of the locations were sampled twice. The results show that the BSI, IOBS and MI can be used as a monitoring tool, when sediment is collected with a grab sampler and mixed. The sediment of a mixed sample can also be used for chemical and ecotoxicological characterisation. The mentum deformities of Chironomidae living in the sediment are not suitable for monitoring, because their density is too low or they are even absent at most sampling sites. The capability to make a good distinction of the rate of contamination could not be evaluated. All seven samples were sediments that were highly polluted. However the classification based on the oligochaete community seemed to give a good indication whether the toxicological risk for the macro invertebrates was due to heavy metals or due to other contaminants.

The BSI is thoroughly tested and evaluated in Flanders. It is a valid method for sediment quality assessment. A lot of valuable information seems to be lost with restricting the determination of certain taxa. The determination of the oligochaete community is promising way of getting more information. A combination of both methods for sediment quality assessment must be considered.

de Deckere, E., W. Beyen, D Van Pelt, B. Veraart & P. Meire, 2001. Biological assessment of sediments: a comparison. Researchgroup Ecosystem Management, UIA, Antwerpen.

Methodology for the establishment of priorities for contaminants in the sediment based on risk assessment

This study describes a methodology that can help managers deciding clear and objectively, which chemicals have to be prioritised during risk management of sediments. The possible risk of the chemicals present in the sediment for living organisms is the determining factor for the prioritisation. The possible risk can be estimated based on the possible exposure of living organism (which depends on production volumes, consumption, application and behaviour) and on the possible harmful risk (which can be estimated based on toxicological and ecotoxicological information).

The described method was previously developed for the prioritisation of pesticides in Flanders (Callebaut & Vanhaecke, 1999). Some additional factors were added. These factors were retrieved from the methodology for the risk assessment of existing chemicals (van der Zandt & van Leeuwen, 1992). Each parameter, which is determining the exposure and the risk, is categorised in these methods, resulting in a score for both the exposure and the risk. The scores are multiplied, which gives a final score that can be used for ranking the chemicals. However some changes had to be made for sediments.

The exposure of chemicals for organisms in sediments will also be determined by the sediment-water exchange. Both the equilibrium between the solid phase and the interstitial water as well as the release of contaminants to the surface water will affect the sediment-water exchange. The human risk of chemicals in sediments is less important, because the exposure of sediments is negligible for humans. The most important way of human exposure is the risk of bioaccumulation throughout the food chain. The methodology was tested for a number of pesticides that are mentioned on the priority list for pesticides. It was shown that the method was appropriate, when all information regarding the specific chemical is available. However more information is needed for a lot of chemicals before a complete list of priorities can be made.

Weltens, R., J. Provoost & C. Cornelis, 2001. Methode voor: Prioriteitstelling en rangschikking van risicostoffen voor waterbodems. VITO, 2001/TOX/R/054, MOL.

Methodologies to analyse chlorinated phenols in the sediment

Specific and non-specific methodologies for the analysis of chlorinated phenols were compared. Only the specific methodologies gave good results. The best methodology was the GC/MS analysis after derivation with acetic acid anhydrid. The extraction is done with ASE with a mixture of hexane-THF. After an alkaline extraction the phenols are transformed into phenyl acetate esters. A recovery rate of 90 up to 130% for soil and 60% up to 130% for sediments was found with this method. Values between 5 and 50 µg/g dry weight can be detected.

Van Deun, M., J. Deighton & G. Vanermen, 2001. Onderzoek naar bepalingmethoden voor gechlorreerde fenolen in sediment. VITO, Vito/MIM/R/091, MOL.

Extraction methods for the evaluation of contaminated sediments

The tuning or harmonisation of the management of the sediments of the rivers Scheldt and Meuse in the different concerned countries (France, The Netherlands and Belgium) is hampered by differences in legal regulations and methodology.

One of the main objectives of this report was to detail the differences in analytical methodology used by France, The Netherlands and Belgium for the physico-chemical quality assessment of the sediments of the river Scheldt and Meuse. It concerned the evaluation of extraction methods (CaCl₂, HNO₃, HNO₃/HCl and HF) for the determination of heavy metals in sediments and the evaluation of extraction methods for the determination of phosphorus in sediments.

Based on the performed experiments concerning the determination of heavy metals in sediments, it is clearly shown that the results acquired with the calcium chloride extraction, representing the bio-available fraction, are very low comparing to the results obtained with the acid extractions. Acid extractions of sediments result in the evaluation of the immobile fraction of the sediment for environmental risk assessment. Acid extraction with HNO₃, aqua regia and HF were evaluated for the determination of As, Cd, Cr, Cu, Ni, As, Pb and Hg in sediments. Comparable results were acquired with the three extraction methods except for Cr and Ni. Elevated concentrations of these elements were obtained after HF destruction in comparison with the HNO₃ and aqua regia destruction method. The vigorous destruction results in the additional extraction of natural Cr-oxides and Ni-oxides, present in the sediment, and in a more complete decomposition of the silicate structure of the sediment.

A method for the analytical determination of different fractions of phosphorus is presented. The method has been selected and validated in a European Standards, Measurement and Testing (SMT) Programme. The method (Williams extraction) has shown to give reproducible results within different laboratories and has been validated by a European inter-laboratory trial. After implementation and validation of the method in our laboratory, several sediment samples from the Rivers Scheldt and Meuse have been extracted and analysed. The maximum bio-available fraction of phosphorus amounted 70% of the total phosphorus content of the analysed sediments.

Vanhoof, C., P. Van Bree & K. Tirez, 2001. Extraction methods for the evaluation of contaminated sediments. VITO, 2001/MIM/R/093, MOL.

Cage experiments

Traditionally, the assessment of pollutants in the environment involves physical and chemical measurements in water and sediments, laboratory experiments conducted under controlled conditions (toxicity

tests) and, to a lesser extent field observations on impacted indigenous populations or. However, due to changes in effluent composition and environmental conditions, water or sediment samples that are representative of temporal fluctuations cannot easily be obtained. As a consequence, both physical and chemical measurements and laboratory toxicity tests will not give a complete or correct picture of the pollution status of a water body. Information on the real biological impact of pollutants can only be obtained by applying long-term in-situ bio monitors.

The aim of this study was to evaluate the applicability of transplanted zebra mussels (*Dreissena polymorpha*) for the assessment of contaminated Flemish rivers. Accumulation of organic pollutants and trace metals was measured after 4 weeks of in-situ exposure. Further, the condition was assessed applying three condition indices and the energy budget.

At 30 Flemish watercourses, caged zebra mussels, originating from a reference site (drinking water basin) were exposed for 4 weeks. After this exposure time, 13 trace metals, 16 PCB's, 11 PAH's and 2 OCP's were measured in the mussel tissue. Besides contaminants, we assessed the energy budget of the mussels (protein, lipid and glycogen content) and three allometric condition indices.

At 8 sites all mussels died and at some other sites mortality was rather high. In some cases (4 sites) this was probably due to accumulation of sediment in the cages. At the others sites mortality was high despite no accumulation of sediments occurred. At those sites mortality can be ascribed to the very high pollutant load.

At most sites accumulation of one or more pollutants was observed. A drawback of the accumulation study is that for a lot of contaminants, already high levels were present in the mussels from the reference site, before deployment in the field. However, an exposure of four weeks seemed to be sufficient to allow elimination of these pollutants when contamination was absent. In the future zebra mussels will be acclimated in the lab four weeks in OECD water before deployment in the field, to ensure the elimination of most of the contaminants from their tissues.

No apparent differences in available energies stores among the sampling sites were measured. A possible reason is that the mussels used in the experiment were not in optimal condition at the moment of exposure. Also, variation among the three (or six) cages at each site is relatively high. Finally, a longer period of exposure might be needed to observe clear effects. Probably mussels were already in a decreased condition at the reference site and four weeks was not sufficient to recover at the clean sites or to further decrease in condition at the more polluted sites.

From this study, we can conclude that trans-located zebra mussels are suitable organisms in monitoring the bioavailability of pollutants in Flemish rivers. High levels of accumulation were measured for both inorganic and organic pollutants at several sampling sites. A good inter-correlation was found between the three condition indices; Shell Condition Index, Tissue Condition Index and Hydration Index, suggesting that they effectively reflect the condition of the organism.

However, a very poor relationship between contaminant load and responses was found. Only with total metal load a significant relationship was found with the hydration index. Differences in energy stores among the sites were rather small. The absence of clear correlations between pollutants and condition or energy budget can be due to other factors than pollution, such as differences in food availability. Another reason might be that a longer exposure period is required to see clear differences in response. An alternative is to acclimatize mussels before exposure in reconstituted water in the laboratory, to allow elimination of the pollutants from their tissues and to optimise their condition.

Bervoets L., R. Smolders, A. Covaci, C.S. Chu, D. Qadah, P. Schepens and R. Blust, 2001. The use of translocated zebra mussels (*Dreissena polymorpha*) for the assessment of polluted sediments in Flemish rivers. University of Antwerp.