European Sediment Research Network

Acronym: SedNet

EC contract No. EVK1-CT-2001-20002

Key action 1.4.1 Abatement of water pollution from contaminated land, landfills and sediments

PRELIMINARY
SedNet recommendations for research priorities related to sediment

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1. Introduction

1.1. Background

At 29 October 2003 SedNet was asked by EC DG Research to provide a summary of SedNet research priorities and recommendations in the light of: river-basin-management, the Water Framework Directive and the European Thematic Strategy for Soil Protection. The summary should give information about short-, medium- and long-term priorities.

Input from SedNet might be useful in order to have 'material' for future research programme developments if the 'role of sediments' will be included in relation to e.g. erosion, transport of soil and contaminants, organic matter, monitoring, land use practices and planning, etc.

SedNet is the acronym for the demand driven, European Sediment Research Network. The SedNet objective is to form on a European scale inter-disciplinary links and trans-disciplinary bridges between scientist, engineers, sediment managers and those responsible for developing and implementing sediment related policy. The SedNet activities are financially supported for three years by the EC under the FP5 EESD programme and within area 1.4.1 on "Abatement of water pollution from contaminated land, landfills and sediments" (Thematic Network project, EC contract No. EVK1-CT-2001-20002, starting date: 1 January 2002). The main deliverable of the SedNet project will be a publication with guidance on sustainable sediment management (SSM).

1.2. Objective

The objective of this paper is to provide (preliminary) SedNet recommendations for short-, medium- and long-term sediment research priorities in the light of the Water Framework Directive/river-basin-management and the European Thematic Strategy for Soil Protection.

1.3. Status of this paper

In the (revised) SedNet Description of Work (DoW) it is also described that SedNet will the deliver a paper with the above objective. The EC funded SedNet project just past 'half-way'. Several SedNet workshops and subsequent to that writing meetings (first half 2004) will still have to take place. In the writing meetings selected sediment experts will be invited to help to prepare state-of-the-art books containing (related to specific sediment issues): an overview of existing knowledge, a digestion and synthesis of that information and based on that conclusions and cutting-edge research recommendations. Therefore, in the SedNet DoW the delivery date for the final paper is set to December 2004.

Due to the pressing deadline, the current paper result from a consultation of only the SedNet Stakeholders Panel, the SedNet Work-Package leaders and their co-workers (for people involved, please see the SedNet Strategy Paper, that can be downloaded via the SedNet website: www.SedNet.org).

Considering the above, the current paper, and the recommendations therein, must be regarded as preliminary and as a starting basis for the final paper next year. When preparing this final paper the whole SedNet community will be given the opportunity to comment to the paper before it is finalised.

1.4. Structure of this paper

In the next sections of the paper the following is described:

Section 2: Delineating and structuring of sediment research issues following the DPSIR Drivers, Pressures, State, Impact Response) framework, starting at State.

Section 3: A one-page summary matrix of the SedNet research recommendations

2. Sediment State, Impact and Response

2.1. State: Quantity and quality of sediments

By state in the DPSIR framework in this connection is meant can we predict at this moment the quantity and quality of sediments in a water body and in its depositional areas (e.g. wetlands, river flood plains and coastal areas).

2.1.1. Quantity of sediments: Sediment delivery

Research is needed on how eroded soil material actually gets to and enters the river system. We know that much soil is eroded from land and river banks, but our understanding of its delivery to rivers and streams is poor. In fact in most cases an empirical value is introduced to link the erosion of soils (e.g. the infamous soil loss equation) to actual sediment delivery to the main water body. A better understanding is a prerequisite for devising and implementing management measures.

Long term research: Quantitative (process oriented) description of the link between erodibility of soils to actual sediment delivery to the water body.

Once this is know it will be possible to determine how sediment budgets at the river basin scale vary throughout Europe, in its contrasting river basins, and how they change with changing land use which affects soil erosion and climate change which affects the hydrology. This will additionally require a stronger link, than exists at present, between the soil, the sediment and climate scientific communities.

Long term research: Integrated research to determine the sediment transport process (including erosion and sedimentation) at the river basins scale as a function of land and water use and hydrological (climate) change in Europe.

Once this is know it will be possible to determine how changing sediment regimes will affect the depositional areas like wetlands and flood plains as well as the morphology of certain coastal areas in Europe but also the sedimentation in navigable waterways and ports.

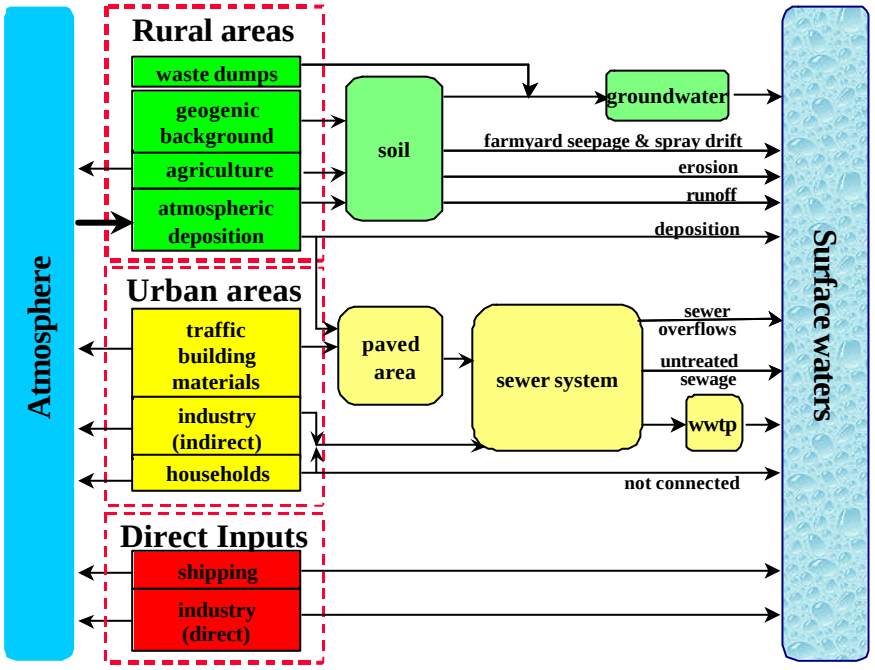
It should be understood that these "depositional" areas are not permanent but subject to both sedimentation and erosion. This is in particular the case for temporary storage in river flood plains, reservoirs or certain wetlands. In this connection more research is needed on the "stability" of these depositional area to global change. This might be an important issue for constructed wetlands and their use as a filter for nutrients (and sediment). However, although this issue is related to sediments its relevance is much wider.

Long term research: more research is needed on the 'stability' of depositional areas like wetlands and flood plains as well as the morphology of certain coastal areas to global change

2.1.2. Quality of sediments

Inputs: diffuse and point sources

The quality of sediments is determined by numerous diffuse and point source inputs originating from rural, urban areas, atmospheric deposition and industry (Figure 1). An important sediment source is eroded soils and hence their quality determines also sediment quality. In order to predict the quality of sediments more information, at the river basin scale, is needed on soil quality. This is not so much related to scientific research more an issue dealing with lack of information: data on soil quality in Europe.



(After Vink, 1999)

Figure 1. Multiple sectors determine both the quantity and the quality of sediments in the water body.

It should be mentioned however, that if information is available it has often a restricted availability, which hampers their inclusion in predictive modelling on sediment quality.

Short term information needs for research 1: Database on soil and sediment quality in Europe and general availability of public data for research needs.

Similar information needs exist with regard to the inputs from point sources, like industrial inputs and sewage treatment plants, on the one hand and non-point sources on the other hand.

Short term information needs for research 2: Databases and general availability of information on point sources, like sewage treatment plants and industrial sources, and non-point sources (including historical contaminated sediments) for research needs (see Figure 1).

These information needs are not strictly research questions for the scientific community but belong to agencies like the EEA and its counterparts in Europe.

Fate and transport of contaminants

Once the contaminants (direct or adhered to soil particles) have entered the water system, depending on water characteristics adsorption-desorption processes take place, which determine the concentrations in solution and the concentrations in the sediment (including suspended particles). Although a lot is known on the adsorption characteristics of priority pollutants on sediments (and soils), very few models exist that describe the fate and transport at the river basin scale.

Short-Medium term Research: Assessment and further development of models describing the fate and transport of contaminants in rivers at the river basin scale.

As mentioned above, basic information is available for current priority chemicals, however, there is a definite lack of information on emerging pollutants such as pharmaceuticals. Nor is their enough information on inputs in the aquatic system to set priorities for their study.

Short-Medium term Research: Identify and quantify those 'emerging pollutants' which are relevant for the aquatic system (and sediments), determine their behaviour in the aquatic system and incorporate them in models at the river basin scale.

2.2. Impact of sediments

The impact of sediments is either due to their quantity, their quality or both. On the global scale the impact of damming has resulted in decreased sediment (and water) supply to the coast and as a result severe modification of the coastal morphology due to increased erosion has taken place in many areas. This issue won't be covered here.

Issues relating to quantity refer in this discussion to harbours and navigable waterways where the quantity of sediment accumulation requires their removal (dredged material).

The quality of sediments has a direct impact on the aquatic ecosystem and biodiversity. For this discussion we will split the discussion in items related to disposal options for dredged material and those methods for assessing the impact of sediments on the aquatic ecosystem either as part of the natural system or determine potential impacts of disposal of dredged material in the aquatic system.

2.2.1. Natural and controlled disposal of sediment and dredged material

Controlled disposal of dredged material have been either relocation in the river system, at sea, sub-aqueous disposal or upland disposal. Options like the separation of contaminants from the sediment or separation by grain size to separate the more contaminated fine sediment fraction can be costly. This also holds for options to minimise contaminants with thermal treatment or addition of absorbing agents. Treatment and reuse of dredged material can on the other hand sometimes be feasible. Controlled upland disposal may also still be economical for the current and NAS countries in the European Union. Important issues in respect to upland disposal, treatment and reuse of dredged material include long term effects, leaching, liability, lifecycle analysis etc. Controlled disposal and dredged material treatment have been studied intensively and the results are summarised in many state-of-the-art reports (e.g.: CEDA, PIANC, POSW, US Army Core of Engineers etc.).

With regard to natural upland disposal (due to/after flooding) there still exist in some countries a "legacy of the past" which refers the storage of what now is considered severely contaminated sediment. This also includes floodplains, which have been contaminated in the past. The change from an aqueous to a terrestrial environment for sediments means a drastic change in (geo)chemical conditions, which may effect the behaviour of contaminants. In

particular cycles of wetting and drying (changing hydrological conditions) might effect this. In this respect more research is needed to address upland disposal as a "legacy of the past".

Short to medium-term Research: Better understanding and predicting the behaviour of non-treated or treated contaminated dredged material, especially in relation to climate change, during and after upland disposal, and better understanding of the impact on ground water, water and soil. This also includes research on ageing and natural recovery potential of contaminated sediments.

A special issue is the behaviour of sediments and associated contaminants in estuaries and coastal zones, where a mixing of inland and marine sediments/suspended particles occurs. Here the handling of dredged sediments has to be differently compared to the marine environment or tidally uninfluenced freshwater systems. Here some of Europes largest ports are located and here, continuously large amounts of sediment have to be dredged for maintenance purposes.

Short to medium-term Research: Better understanding and predicting the behaviour of sediments and associated contaminants in the interface between the river and sea (estuaries, coastal zones)

2.2.2. Sediments as part of the ecosystem

The SedNet Strategy Paper (see: www.SedNet.org) as well the general literature on wetlands, floodplains etc. demonstrate the importance of sediments and its quality on the ecosystem and its bio-diversity. In this section focus is on testing methods to assess potential impact of (contaminated) sediments on the aquatic system as such or as a tool to predict the impact of relocation of dredged material in the aquatic environment.

Many tests to determine sediment quality have been devised of the past years. They start from simple chemical test on contaminant concentrations, to bio-assays/Triad tests or even field trials. Common across Europe and (partly) embedded in legislation are the chemical tests on concentrations. A number of countries have endeavoured in more (expensive) and complicated bio-assay methods due to the fact that chemical tests only detect a very limited No. of the potential available contaminants and hardly give an indication of the bio-availability of contaminants or their mixture toxicity. However, comparisons are lacking taking into account the diversity of European conditions as well as economic criteria on costs. The latter might be of particular importance for NAS countries.

Short- to mid-term research: Integrative assessment of currently available sediment quality assessment tools taking into account their limitations and costs, aiming to harmonisation in Europe and making these tools applicable for (routine) monitoring/assessment at the basin scale.

Furthermore, more and more research results demonstrate that severely contaminated sediment not always results in toxic effects in bioassays and/or a negative impact to ecology. Sometimes even the opposite happens: sediment that appears to be chemically clean (toxicants overlooked?) gives negative effects in bioassays and/or a negative effect to ecology.

This demonstrates two things: 1) that it is useful to think of implementing effect monitoring complementary to chemical monitoring and 2) that we need to improve our understanding of the relation between sediment contamination (hazard) and its actual risk to the ecosystem functioning (ecological quality). For this we need multidisciplinary research, integrating already existing techniques. These are: physical/chemical techniques, effect monitoring techniques (e.g. bioassays, functional monitoring, etc.) and ecological monitoring/assessment (community surveys) techniques. To advance science in this field it also needs the complementary integration of 'bridging tools' like Toxicity Identification Evaluation (TIE), Model Ecosystems and modeling.

Short- to mid-term research: improve our understanding of the relation between sediment contamination (hazard) and its actual risk to the ecosystem functioning (ecological quality)

2.3. Response: Stakeholders, regulations, policy……

Europe faces regulations like the Water Framework Directive, Thematic Strategy for Soil Protection, Habitats and Birds Directive, Marine Strategy etc. (Figure 2). These regulations influence the best management practices in sediment management (e.g. sustainable relocation, wetland restoration, mudflat regeneration, etc.).

The response factor and involving stakeholders, dealing with regulations and taking policy into account has been hotly debated within SedNet. Figure 2 is a simple presentation of the complex issues involved. On the one hand sediment quality and quantity is determined by human and natural processes/activities in rural, urban areas and by direct inputs. These activities are subject to (partly) by EU directives but are also heavily influenced by global change. Global change includes changes in the industrial landscape as well as demographic changes in Europe.

These responses (e.g. directive) as well anticipated global-European change have determined sediment quality and will determine future quality. On the other hand sediments (with their contaminants), after introduction in the river basin system, become deposited in harbours, floodplains, wetlands and in the coastal area. These areas (output side) are subject to different directives, agreements and local and regional policy. To state it differently: the regulations and societal pressures on the input side are different from those on the output side. One of the functions of SedNet is to form a bridge between these conflicting or sometimes emerging joint interests.

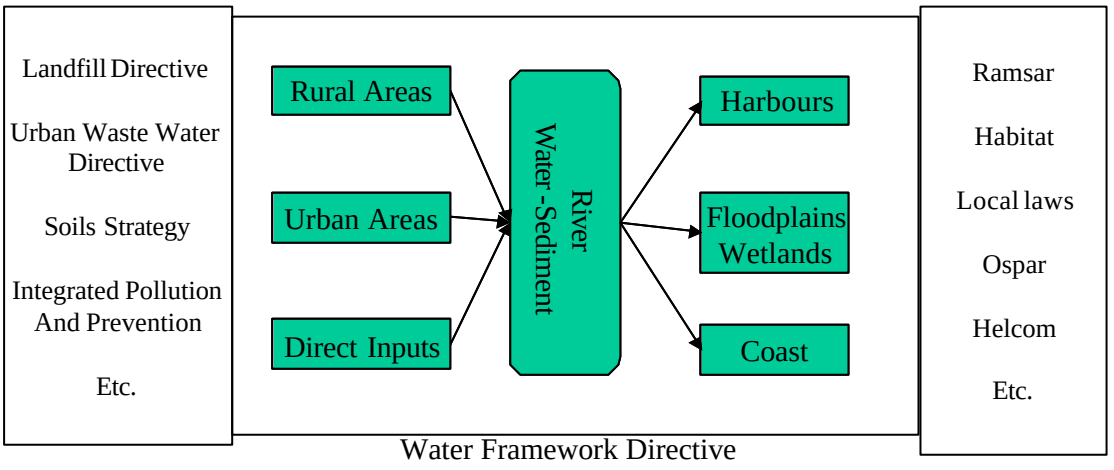


Figure 2. Policy, directives, agreements and biophysical parameters which have to be taken into account for an integrated view of the sediment issue (including the EU marine strategies on the right).

This 'bridging function' contains several research questions, which have to deal with interaction between different policy domains, involvement of stakeholders (and different interests) in the policy process and the multilevel governance character of the policy process.

The interaction between different policy domains that have an effect on sediment or are affected by sediments, and the interaction with different interests (stakeholder involvement) asks for new policy processes. These processes should have an architecture that can deal with these interaction issues, acknowledges the different stakeholder perspectives and interests, applies new knowledge production and -use processes (more "expert-fed" than "expert-led") and leads to joint actions.

Short term research: Research about new architectures for policy processes with respect to sediment issues that enable interaction of several involved policy domains, interaction with stakeholders, new joint knowledge production processes and joint actions.

One of the big bottlenecks for the implementation of EU-policies is the multi-level character of it and the dividing line ('watershed') between strategy and actual implementation. The multi-cultural character of it poses extra problems. This asks for new approaches and probably new institutional arrangements, that can facilitate the connection between the several involved policy levels (EU-national-local) as well as the connection between strategy and implementation with respect to sediment policy. In such a new approach one might expect that support of the implementation and 'feedback and learning' play an important role.

Short term research: Research about how the connection between the different involved policy levels and between strategy and implementation can best be established.

Furthermore, a research issue is how global change, European change and local change in industrial landscape, changing land use and demography affects sediment supply and its quality. This requires the downscaling of readily available scenarios (IPCC, OECD, country etc.) to the river basin scale and see how long term changes will effect sediments and whether management actions are required. This might be in particular be important for NAS countries were socio-economic changes are to be expected.

Short term research: Evaluation (social/economic/technical/environmental) of source control programs and a cost benefit analysis of risk reduction through source control, including the management of historic contamination.

Long term research: Downscaling of global, European and country scale socio-economic scenarios to the river basin scale and their effect on sediment quantity and quality and research into the development of best management to comply with current and future EU regulations.

3. Research recommendations summary matrix

See next page

SEDNET recommended research priorities	Short-term (< 5 years, addressing actual/urgent needs)	Medium/Long-term (> 5 years, addressing actual and future needs)
Generic characteristics / research typology	Main issues: contamination, source control, land & basin management (incl. floodplains) Keywords: improved understanding (from contaminant fate to system functioning); contamination related to quality; standardisation of basic tools; stakeholder & public participation; definition of a common language	Main issues (complementary to short-term): erosion, organic matter, salinisation etc. Keywords: integration of quality and quantity; concepts, methods, integrated approaches; sediment quantity criteria; understanding and mitigation; implementation of basic tools; development of complementary tools; stakeholder & public participation
WFD/river basin specific: Key-issue: link sediment to chemical water quality	Improve our understanding of the relation between sediment (including suspend particles) contamination and water quality. Thus we need to focus on conventional pollutants, where there is a need to improve our understanding at basin scale, as well as on emerging pollutants, where there is a need to identify and quantify the relevant ones for sediment and then select them for improving of our fundamental understanding.	Use the gained knowledge (see left) to work on: 1) Techniques and methods to mitigate the impacts of contaminated sediment to water quality. 2) A harmonized method/approach to monitoring the 'release' of contaminants from sediments, suitable for use at the basin scale.
Key-issue: link sediment to ecological quality	Improve our understanding of the relation between sediment contamination (hazard) and its actual risk to the ecosystem functioning (ecological quality). Furthermore, we need an integrative assessment of currently available sediment quality assessment tools taking into account their limitations and costs, aiming to harmonisation in Europe and making these tools applicable for (routine) monitoring/assessment at the basin scale.	Use the gained knowledge (see left) to work on: 1) The harmonization at basin scale of the Triad-method (integration of chemistry, effect monitoring and ecological monitoring) for use of (routine) monitoring of sediment quality; 2) Techniques and methods to mitigate the impacts of contaminated sediment to ecological quality.
Key-issue: source control (local and diffuse)	Improve our understanding of the (and thus also our capability to predict/model) fate of contaminants: from emission (up stream) to adherence to soil and/or suspended particles to sedimentation & re-suspension (downstream). For this we need multidisciplinary research performed at full basin scale, in which already existing techniques (chemical, biological, modelling) are integrated. This 'beta'-information is part of the information needed to define solutions for controlling of these sources. Besides that we need to perform 'gamma' research: 1) evaluation (social/economic/technical/environmental) of source control programs, 2) cost benefit analysis of risk reduction through source control, including the management of historic contamination 3) identification of relevant stakeholders at basin scale and 4) find ways to get stakeholders and public involved in, and committed to the definition of sustainable solutions (see further below).	Improve our quantitative (process oriented) description/understanding of the link between erodibility of soils to actual sediment delivery to the water body. Furthermore, we need to continue to work on sustainable solutions for controlling of our sources, amongst others by: 1) downscaling of global, European and country scale socio-economic scenarios to the river basin scale and their effect on sediment quantity and quality and by 2) research into the development of best management to comply with current and future EU regulations.
Soil Strategy specific: Key-issues: legacy of the past (e.g. floodplains) and upland disposal of sediment/dredged material	Improve our understanding of (and thus also our capability to predict) the fate of sediment or dredged material associated contaminants when sediment is deposited upland (naturally or by man) especially in the context of perturbations such as wetting-desiccation due to an increase in the frequency of flooding due to climate change. This also includes research on ageing and natural recovery potential of contaminated sediments and a better understanding of the impact on ground water, water and soil ecosystems. This 'beta'-information is part of the information needed to define sustainable solutions for our legacy of the past or for dealing with our immense volumes of dredged material. Besides that, we need to perform ' gamma' research in order to: 1) develop new architectures for policy processes with respect to sediment issues that enable interaction of several involved policy domains, interaction with stakeholders (including public), new joint knowledge production processes and joint actions; 2) find the way to establish the best connection between the different involved policy levels and between strategy and implementation. The definition of a common language will be part of such research. This process will also help to define 'demand-driven' research priorities. A continuous investment in networking (e.g. continuation of SedNet) is essential to that.	Integrated research to determine the sediment transport process (including erosion and sedimentation) at the river basins scale as a function of land and water use and hydrological (climate) change in Europe. More research is needed on the 'stability' of depositional areas like wetlands and flood plains as well as the morphology of certain coastal areas to global change