Martin Forsius

finLTSER

Finnish Long-Term Socio-Ecological Research network (FinLTSER)

www.ymparisto.fi/syke/lter   www.environment/syke/lter

Humans interact intensively with the rest of nature: Will ecosystem services remain resilient?

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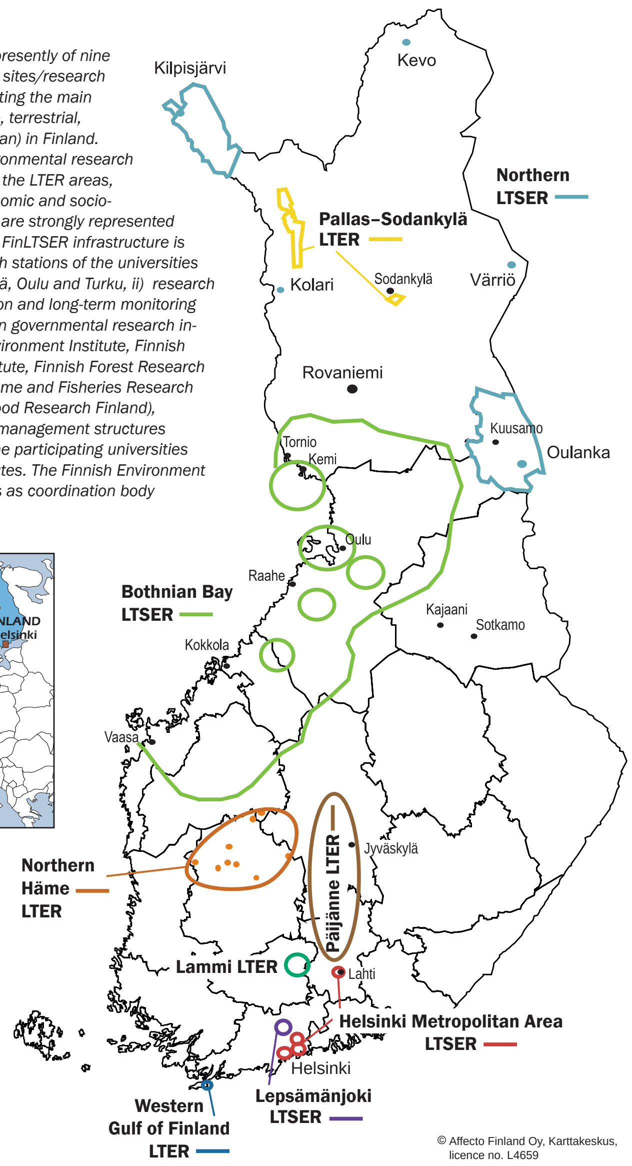
Coordinated Finnish research infrastructure brings together high-level research sites and scientists

FinLTSER aims to be an integrated, multi-functional, well-instrumented network of infrastructures for ecological and socio-ecological research and monitoring. It is a research network of scientists, collectively engaged in and dedicated to multi- and interdisciplinary long-term and spatially large-scale research and monitoring in ecological entities including the human dimension.

These long-term ecosystem research platforms support, enhance and promote the interdisciplinary investigation of long-term biodiversity and ecosystem processes at varying spatial and temporal scales. Through the national and international LT(S)ER networks, FinLTSER is stressing socio-ecological and socio-economic research.

FinLTSER network was established in 2006, and it combines expertise and resources of both universities and main governmental institutes. FinLTSER is a part of international LTER-networks by being a formal member both in the Europe-LTER and the International LTER (ILTER) -networks. FinLTSER provides the Finnish contribution to observatories component of the proposed European-wide LIFE WATCH initiative. FinLTSER and LIFE WATCH were formally accepted as key national-level Research Infrastructures (RI) and were included into the national RI-roadmap in December 2008.

FinLTSER consists presently of nine highly instrumented sites/research platforms, representing the main ecosystems (marine, terrestrial, lake, sub-arctic, urban) in Finland. Ecological and environmental research is the main focus in the LTER areas, whereas socio-economic and socio-ecological research are strongly represented in the LTSER areas. FinLTSER infrastructure is formed of i) research stations of the universities of Helsinki, Jyväskylä, Oulu and Turku, ii) research sites, instrumentation and long-term monitoring programmes of main governmental research institutes (Finnish Environment Institute, Finnish Meteorological Institute, Finnish Forest Research Institute, Finnish Game and Fisheries Research Institute, MTT Agrifood Research Finland), and iii) information management structures and databases of the participating universities and research institutes. The Finnish Environment Institute (SYKE) acts as coordination body of FinLTSER.



Global change forms a wide framework for the research in FinLTSER

The main research themes within FinLTSER cover a wide spectrum of ecosystem studies, such as:

- research and monitoring related to the LTER-Europe and ILTER core areas (climate change, global water circulation, biogeochemical processes, changes in biodiversity), and other ecosystem processes and disturbances.
- ecosystem services, societal and other socio-economic pressures on the functioning of the ecosystems, effects on the local communities of nature conservation and resource exploitation, and local environmental conflicts.

FinLTSER aims

- To provide a national infrastructure for long-term site-based ecosystem and biodiversity research in Finland, including climate change impacts
- To provide the Finnish contribution to the European LTER-network (LTER-Europe) and global LTER-network (ILTER)
- To provide the Finnish contribution to observatories component (terrestrial and marine observatories) of the proposed international ESFRI-initiative LIFE WATCH.
- To collaborate with the international ESFRI-initiative ICOS (Integrated Carbon Observing system)
- To become an attractive alternative for cooperation and visits by talented researchers from abroad
- To facilitate stakeholder learning and education in all levels in the area of conservation and sustainable use of ecosystem services

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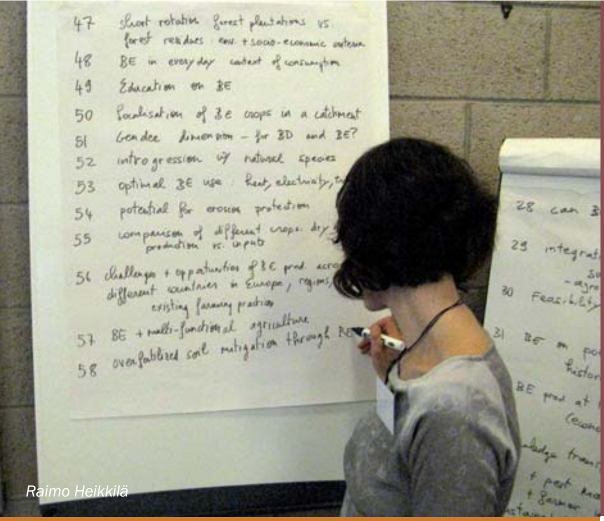

Identifying the knowledge gaps with stakeholders

An interdisciplinary framework for Long-Term Socio-Ecological Research platforms (LTSERs)

www.environment.fi/SYKE/bioenergycase

The long-term biodiversity research network of Europe, the ALTER-Net, links more than 600 researchers and 25 research institutions.

Eeva Furman, Taru Peltola & Riku Varjopuro
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The move from ecological to socio-ecological research has raised new challenges in building research strategies

Although disciplinary research is still commonly perceived as the "good science", interdisciplinary research is widely recognized as an asset in tackling complex environmental problems such as biodiversity loss. Moreover, the most lasting influence of research comes, not from information transferred to practitioners, but from practitioners and researchers co-creating knowledge.

European long-term biodiversity research network (ALTER-Net) developed a framework to tackle the most relevant short and long term future challenges of biodiversity

This framework aims to identify key gaps in knowledge and to bring existing knowledge into one pool. The framework was piloted by identifying research needs related to interlinkages between bioenergy and biodiversity.

The process was built around a two-day workshop but included also collection of pre-material and post-collaboration within the formed teams. The total number of participants in these events was 40 representing several disciplines, 12 European research institutions and 4 stakeholder organisations.

A specific dialogue method was used in the workshop. In the dialogue method, special attention was paid to how people encounter each other in an equal manner and how principles of open innovation can be applied.

Basic ideas adopted in the dialogue method:

- generating a few jointly endorsed research ideas requires a great number of ideas to start with
- holding back critique in the early phases of the process is important to ensure that even the weakest voices get through
- accepting various interpretations of the topics is useful because they may open up new avenues for collaboration and ways of thinking

What can the pilot tell us about the interdisciplinary framework?

The method allowed for a diversity of ideas, but finally focussed attention on selecting those ideas that would lead to designing joint projects.

Significant number of ideas was excluded along the process. This is a paradoxical feature of interdisciplinarity: when the focus is on the smallest common denominator and there is an aim to build common understanding, diversity is lost.

Loss of diversity risks novelty, but partly that can be saved by asking participants to attend to novel, wild, intellectually attractive, ambiguous, rather than merely important ideas, they tend to pick ideas differently and diversity of ideas is maintained.

The process of exclusion and inclusion of ideas involves power relations: who decides which ideas are important and who dominates the process. Group size of 4–5 worked better than large groups.

The topics discussed during the bioenergy-biodiversity workshop remained rather broad and policy-oriented. For ecologists such framings of topics do not necessarily provide the easiest entry, but for more policy-oriented participants the way topics were structured ensured that outputs do not evolve at a distance from policy maker needs.

This method gives the seeds for collaboration and future research. The final task of the framework is to ensure that the new teams roll the ball forward.

Interdisciplinary dialogue method facilitates the development of research strategies for sustainability.

The working method applied had five main steps; steps 2–5 involved group exercise:

1. Background materials and pre-workshop exercises to introduce previous research and knowledge
2. Brainstorming to produce as many new ideas as possible linked to the topic
3. Preliminary selection and processing of ideas
4. Sorting out and selection of ideas
5. Further development and presentation of ideas and recruitment of research groups

Identifying research needs related to interlinkages between bioenergy and biodiversity; The framework funneled four research plans from 262 ideas in two days by using a method developed to enhance interdisciplinary and transdisciplinary dialogue.

Output of step 1

262 ideas

62. Low-input – high output systems; 63. Tree leaves to be used; 64. Strategy for compost restructured; 65. Co-degestation; 66. Methods of valuing biodiversity to support decisions; 67. How to value: abundance /rarity; 68. Tilting point in adding bd value with cultivation; 69. Scale of biodiversity: how to value levels, scales; 70. Good & bad biofu[illegible] biomass into existing agrisystems (also produc[illegible]mass); 72[illegible] Biomass crops / biol. Invasions; 73. Biomass [illegible]munities; 74. Indicators for sust. biomass pro[illegible]iduals +biomass prod.; 76. Import of biomass & impact on ecology in developing countries; 77. Global feedback mechanisms; 78. Aliens; 79. Genetic conservation + bi[illegible]ps; 80. Market value of bd; 81. bd value of abandoned far[illegible] increase value; 83. Stable functions; [illegible]wables (others the bioenergy) altern[illegible]ances of biomass schemes; 87. Representative studies that can be interpreted on European scale; 88. 2nd generation biofuels; 89. Urban green areas as source of boenergy; 90. Indirect land use change > bioenergy impacts; 91. Use of invasive species as biomass; 92. Use of weds as source; 93. Impact of transportation on invasive species dispersal (contamination); 94. Green waste; 95. Aesthetics and

Output of step 2

1. Best practices & communication
2. Decision support
3. Integrated multi-level policies and win-win solutions on BD On biodiversity, environment, energy and food:
4. Sustainability impact assessment of BE development in multifunctional landscapes (+ ecosystem services) in Europe
5. Multifunctional analysis of biomass production regimes
6. Challenges and opportunities of BE production in multi-functional land-use systems in Europe
7. Bioenergy landscapes
8. Design of a (framework) new BD friendly bioenergy landscape (cradle-to-cradle)
9. Not-economical forest & agricultural lands > energy prod
10. Ecol. carrying capacity and resilience of harvested ecosystems (or you are going to harvest)
11. Monitoring of trends in biodiversity under different harvesting regimes (forests, agriculture...) including biomass production regimes
12. Involvement of BDin sustainability criteria
13. Global consequences

Output of step 3

Topic 1: Integrated multilevel policies on bioenergy, biodiversity, environment and food

Topic 2: Integration of sustainable bio-energy pathways in multifunctional landscapes

Topic 3: Good practices and sustainability indicators for bioenergy

Topic 4: Impact of EU bioenergy policies on the biodiversity and ecosystem services outside Europe

LTER-Europe has encouraged the national networks to establish long-term socio-ecological research (LTSER)- platforms

One major step towards interdisciplinarity has been the establishment of broad long term socio-ecological research (LTSER)-platforms. There are 19 of LTSER platforms in Europe, some of which have evolved from the traditional LTER-sites, while others have taken the LTSER approach right from the beginning.

In LTSER-platforms, researchers from a wide range of disciplines collaborate with each other and with the stakeholders to reflect the societal realities, through developing and implementing a joint research strategy. Interdisciplinarity is a major issue in the platforms.

The development of research strategies for these LTSER platforms raise several challenges. This phase influence, which researchers, disciplines and research questions remain on the platform and which step out due to frustration or loss of interest/ possibilities.

LTSER-platforms: towards more open and socially sensitive development of research strategies

The challenges of building research strategies for the newly established LTSER platforms need to be taken seriously to ensure that all disciplines find the collaboration fruitful. Also, revising already existing research strategies opens opportunities for building more coherent agendas which involve and inspire researchers and stakeholders.

The ALTER-Net´s interdisciplinary framework provides a useful model for building long term research strategies. The main steps of building LTSER platform research strategies could include:

- defining an overarching theme
- making a synthesis on existing knowledge beyond disciplines and sectors
- organizing workshop for researchers and stakeholders, using a facilitator
- using dialogue method to facilitate interdisciplinary and transdisciplinary interaction: brain storming, organizing and selecting ideas, building plans
- having post-workshop sessions to follow based on need

Graphic design Marja Vierimaa

Do pesticides pose a risk for Finnish freshwater biota?

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Scope of the study

- Monitoring results of pesticides in Finnish river waters are compared with predicted no effect concentrations (PNEC).

Material and methods

- Water samples were taken from 10 rivers and 5 tributaries (Map 1 & Table 1) during four sampling periods: year 2007–2008 (V–IV) and summers (V–X) 2005, 2006 and 2008.
- In 2005, 2007 and 2008 pesticides were analysed using multi-residue methods, which were able to detect 98–150 compounds (Lahti, Ramboll). In 2006 samples were first frozen and then 24 compounds were analysed (Jyväskylä, IER).
- Mean concentrations were calculated for all detected compounds site- and sampling period-specifically. Concentrations below quantification limit were set to zero. The mean concentrations were compared with PNEC values.
- The PNEC values were derived from three sources: (1) The environmental quality standard (EQS) value (National decree 1022/2006) was selected whenever available. (2) The Swedish target values (Kemi 2008). (3) If neither of the previous was available, the value was calculated from ecotoxicological data (Footprint 2006) by dividing the lowest found NOEC, LC50 or EC50 value with an appropriate assessment factor (Table 2).

Results

- Altogether 55 compounds were detected: the most commonly found are shown in Table 3.
- In general, the site specific mean concentrations were lower than the derived PNEC values indicating low risk for freshwater biota. Most of the samples were taken during summer and all year round sampling would lead to even lower mean concentrations.
- Two PNEC exceedings were observed: The mean concentrations of MCPA in Savijoki (38 µg/L) and in Kinarehenoja (3.5 µg/L) in 2006 were higher than PNEC (1.6 µg/L). This demonstrates that pesticides may locally, especially in smaller upstream sites, pose risk to freshwater biota. The peak concentration of MCPA in Savijoki was even higher than the LC50 value for aquatic plants.
- The quantification limits of some chemicals were higher than their PNEC values. E.g. traces of endosulfan and terbutryn were detected (concentration below quantification limit).

Future

- According to Water Framework Directive (2000/60/EC) the annual average concentrations should not exceed EQS in any surface water in EU by 2015.
- In future, this might become an even more challenging task, because the need for plant protection is increasing due to climate change.
- The monitoring of pesticides in surface waters should be developed in order to find the potential risk areas. This would require catchment based knowledge about pesticide usage.

Acknowledgements

- The regional environmetal centres of Southwest Finland, West Finland, Uusimaa and North Ostrobothnia carried out most of sampling. Elina Lukkari, Lotta Koskela, Hannamari Luukkanen, Anna Paloheimo and Teresa Valonen took part to the project in SYKE during summers.
- Ministry of Environment (YM) and ministry of agriculture and forestry (MMM) have funded the pesticide screening project (2004–2006) and MMM the monitoring since 2007.

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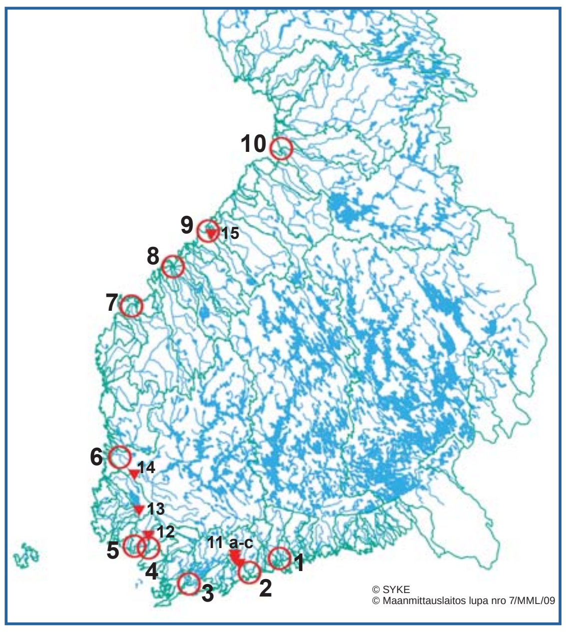
Table 1. Sampling sites (same codes as in Map 1), the number of site specific sampling periods and the total number of samples included into the results. Only sites and sampling periods with at least 4 samples/period are included into this study.

Code	River	Upstream Area (km²)	Sampling periods	Number of samples
1	Porvoonjoki	1 270	4	32
2	Vantaanjoki	1 700	4	32
3	Mustionjoki	2 050	1	12
4	Paimionjoki	1 050	4	34
5	Aurajoki	874	4	35
6	Kokemäenjoki	27 000	4	27
7	Kyröjoki	4 920	2	22
8	Ähtävänjoki	2 050	1	12
9	Lestijoki	1 370	2	10
10	Oulujoki	22 840	1	5
	Tributaries			
11a	Lepsämänjoki	214	1	12
11b	Lepsämänjoki	83	2	13
11c	Lepsämänjoki	22	1	5
12	Savijoki	15	1	6
13	Yläneenjoki	200	1	5
14	Löytäneenoja	6	1	8[a]
15	Kinarehenoja	12	2	8
Sum			36	278

a) Löytäneenoja data from sampling period I–VIII 2005



Map 1. *Sampling sites*

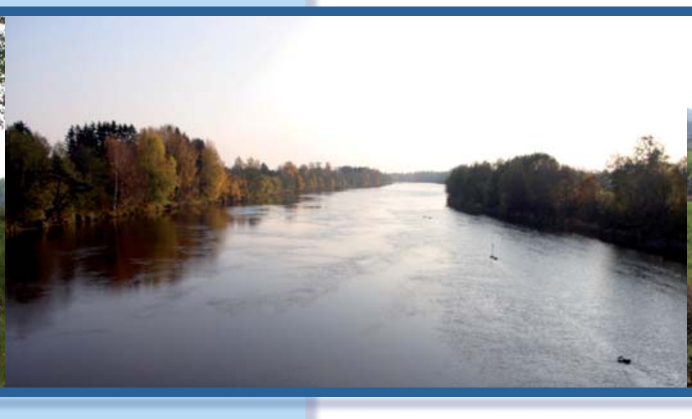
Table 2. The used assessment factor

Number of NOEC values of species representing different trophic levels	≥3	2	1	0, but at least three L(E)C50 values
Assessment factor	10	50	100	1000

Table 3. The most commonly detected pesticides in Finnish rivers in the decreasing order of detection frequency. The median and maximum values of site and sampling specific mean concentrations can be compared to the "predicted no effect concentration" (PNEC).

Compound	Type	Quantification limit µg/L	Detection % 2005	2006	2007–8	N	Site specific mean c. (µg/L) Median	Max	PNEC µg/L
MCPA	H	0.01 – 0.05	72	42	71	36	0.055	37.83	1.6
diklorprop + -p	H	0.01 – 0.05	44	4	59	36	0.005	0.880	10
mecoprop + -P	H	0.01 – 0.05	33	2	61	36	0.002	0.332	20
ethylentiourea (ETU)	M	0.01 – 1.00	Na	25	30	3	<	0.032	200
bentazone	H	0.01	16	Na	29	29	<	0.065	30
azoxystrobin	F	0.005 – 0.01	11	20	13	28	<	0.006	0.9
diuron	H, O*	0.01	0	Na	19	27	<	0.132	0.2
tralkoxydim	H	0.01	6	Na	14	27	<	0.024	100
dimethoate	I	0.005 – 0.02	10	5	7	36	<	0.055	0.7
AMPA	M	0.05	Na	Na	10	2	<	0.027	500
glyphosate	H	0.10	Na	Na	10	2	<	0.060	100
propiconazole	F	0.01 – 0.02	0	Na	10	17	<	0.014	7
metamitron-desamino	M	0.01 – 0.02	7	0	8	36	<	0.043	251
thiamethoxam	I	0.05 – 0.1	0	Na	7	17	<	0.030	0.1
2,4-D	H	0.01 – 0.05	0	0	8	36	<	0.018	58
metsulfuron-methyl	H	0.01 – 0.02	0	Na	6	17	<	0.010	0.02
linuron	H	0.005 – 0.02	8	5	2	36	<	0.070	1
atrazine	H	0.005 – 0.01	6	0	5	36	<	0.001	0.6
terbuthylazine-desethyl	M	0.01	2	Na	5	27	<	0.002	?
terbuthylazin	H	0.005 – 0.01	7	Na	3	27	<	0.005	0.02

Type: H = herbicide, I = insecticide, F = fungicide, M = metabolite, O = other (diuron is used as biocide e.g. in paints)*
Na = not analysed
N = number of site and sampling period specific mean values
< = median concentration is lower than quantification limit
PNEC = predicted no effect concentration, ? = not known



Graphic design Marja Vierimaa

Application of catchment scale model INCA-SED to Finnish catchments

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Background

The main aim of this study was to test the applicability of the sediment delivery model INCA-SED to Finnish catchments. The term 'sediment delivery' has been widely used to describe the combined processes of sediment movement within a catchment. These processes include both soil erosion on slopes and fluvial export.

The INCA-SED model

The INCA-SED (Integrated Nutrients from CAtchment-Sediment) model is based on semi-distributed approach. The main river channel is divided into series of reaches and the land area that drains into each of these reaches is defined as a sub-catchment. The basic modeling unit of soil erosion processes is then a land use class in the sub-catchment. In addition, the model incorporates environmental data of hydrometeorology, land use, erodibility and catchment and channel morphology.

Model set-up to study catchments

The INCA-SED model is applied to four small study catchments (Fig. 1) which represent typical land use and soil types in Finland (Table 1). Two of the study sites (Mustajoki and Haarajoki) are forested headwater catchments around Lake Pääjärvi. The third one discharging to this lake, Luhdanjoki catchment, has a higher percentage of agricultural land. The rivers have different morphological characteristics varying from a ditch to a small river (Fig. 2). The fourth study site, the Savijoki catchment represents intensively cultivated areas in south-western Finland. The INCA-SED model is calibrated by using GIS and water quality monitoring databases of SYKE. Hydrological input is derived from the results of the operational Watershed Forecasting and Simulation System.

Results and discussion

Analysis of covariance (ANCOVA) indicate a significant relationship between discharge (Q) and suspended sediment (SS) concentration in the rivers discharging to Lake Pääjärvi. This relationship, however, varies among the catchments (Table 2) and is captured in INCA-SED applications (Fig. 3). Even small differences in river morphology, flow velocity and soil types seem to have an influence on SS concentration. The Savijoki observations are divided into two sets, spring observations (March-April) and autumn observations (October-November). In the ANCOVA analysis there are significant difference between these two sets, and a significant relationship exists between Q and SS only in autumn (Table 2). The INCA-SED model appears to be able to capture this seasonal behaviour (Fig. 4) of SS concentrations in the Savijoki river. However, some individual SS peaks are not simulated (Fig. 5). The semi-distributed structure of the INCA-SED model is not able to take into account all of the stochastic or incidental events of erosion and sediment delivery processes. Even then INCA-SED seem to be a suitable tool for evaluating effect of land use change on erosion and SS delivery in Finland.

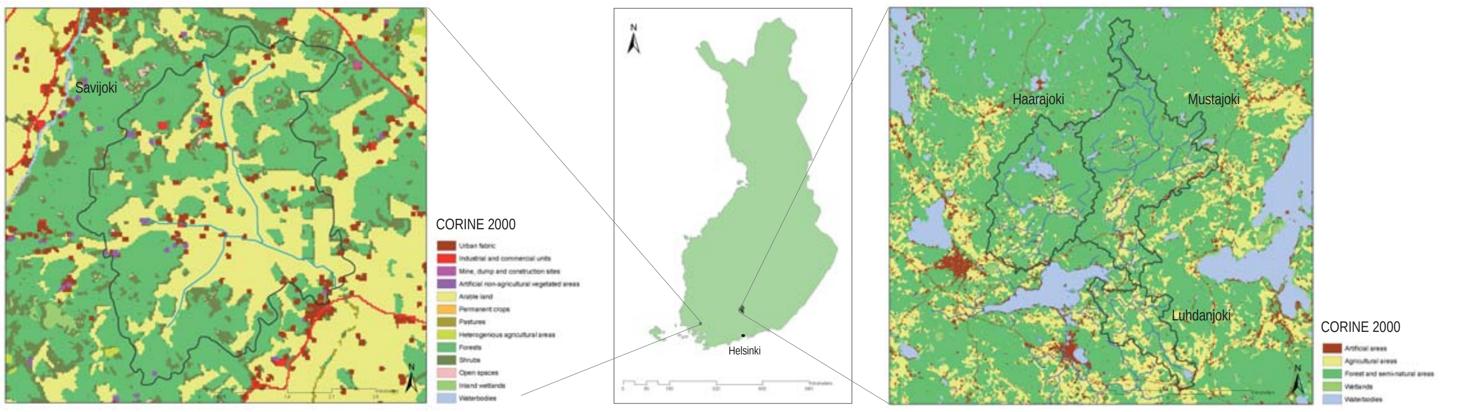


Figure 1. Location of the study catchments in Finland

Figure 2. Rivers Haarajoki, Mustajoki and Luhdanjoki

Catchment	Area	Runoff	Land Use				Soil types		
			Agriculture	Set-aside	Forest	Main crops	Till and coarse sand	Fine sand and silt	Clay
	km^2	mm	% of area	% of area	% of area		% of area	% of area	% of area
Haarajoki	58	212	12	11	71	Barley	64	18	0
Mustajoki	81	234	13	19	68	Barley, Sugarbeet, Grass	68	11	1
Luhdanjoki	25	-	33	19	48	Barley, Sugarbeet, Grass	42	34	10
Savijoki	15	369	36	3	61	Barley, Grass, Oilseed	51	0	49

Table 1. Land use and soil types of the study catchments

Catchment	Coefficient	Significance of coefficient	Significance that observed and simulated differ	
	$mg\ l^{-1}/m^3\ s^{-1}$	*p*-value		*p*-value
Haarajoki	53	***	no	0.356
Mustajoki	12	***	no	0.799
Luhdanjoki	112	***	no	0.179
Savijoki, spring	–	–	–	–
Savijoki, autumn	152	***	no	0.547

Table 2. Effect of discharge on suspended sediment concentration in the ANCOVA analysis

Figure 3. Simulated and observed SS concentration vs. discharge in the rivers Haarajoki, Mustajoki and Luhdanjoki

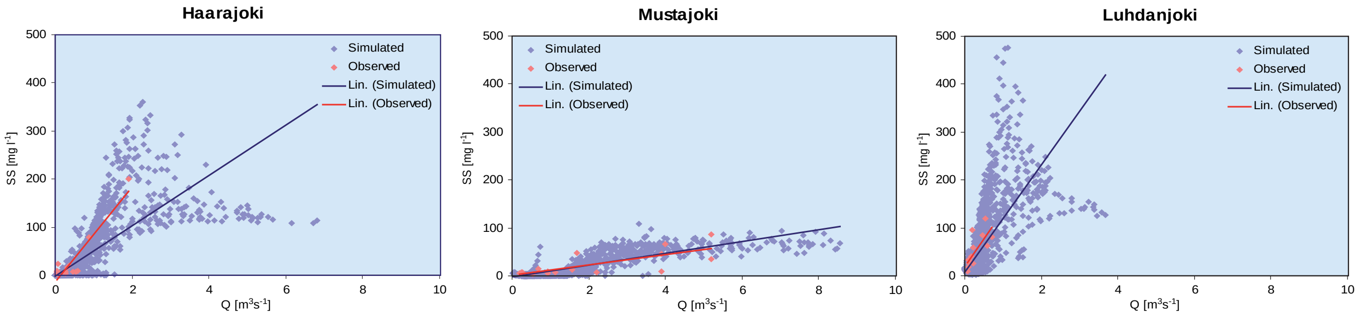


Figure 4. Simulated and observed SS concentration vs. discharge in the river Savijoki in spring (March-April) and in autumn (September-October)

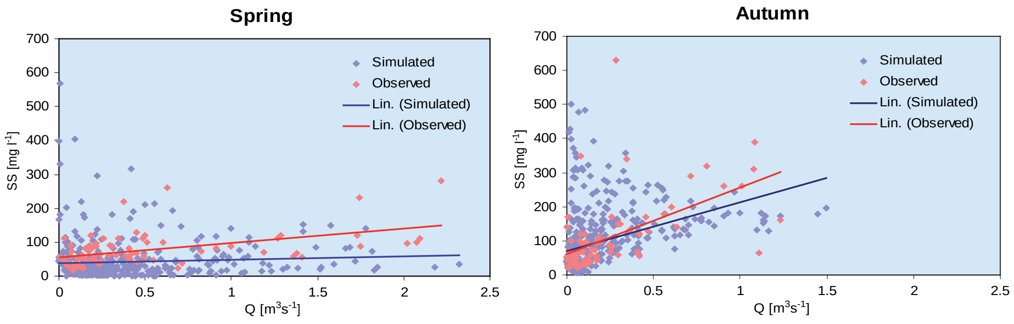
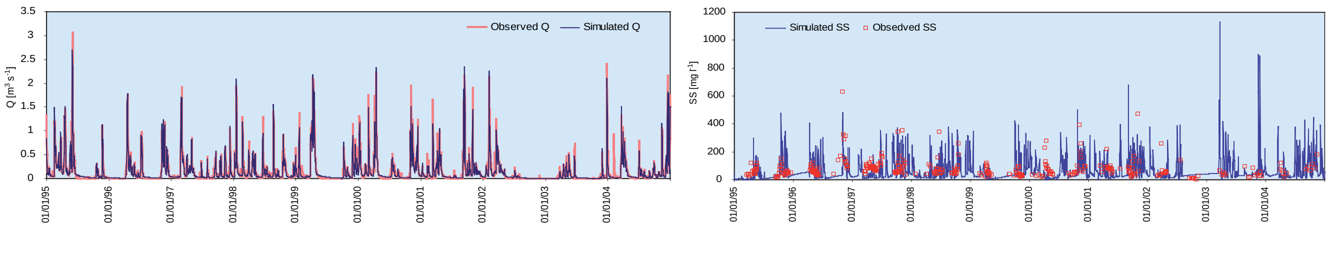


Figure 5. Observed and simulated discharge and suspended sediment concentration in the river Savijoki



Graphic design Marja Vieremaa

Applying material flow analysis to an industrial symbiosis

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In industrial ecology (IE), industrial symbiosis (IS) studies are focused on the physical flows of materials and energy in local industrial systems (e.g. Chertow, 2000). Instead of focusing solely on individual system components (a single process or organisation) entire systems (firm and process networks) are analysed thereby avoiding problem transfer between system components.

Although several examples of industrial symbiosis type of arrangements have been described in the literature, there has been a lack of quantitative tools for the assessment of local sustainability (Wolf, 2007; Albino et al., 2003). In the present study environmental input-output analysis is applied for analysing material flows of an industrial park in the Kuusankoski town, in Southeast Finland in 2005. The park is centred around a pulp and paper factory, the Kymi plant of the UPM Kymmene Corporation. Other actors of the park consist of three chemical plants, one power plant, water purification plant, sewage plant and a landfill. The park also has close interaction with a regional energy supplier (the symbiosis' power plant sells electricity and district heat to the energy supplier) and a municipal sewage plant (the sewage plant of the symbiosis receives sludge from the communal plant).

Material and methods

The material flows of the system were studied applying environmental input-output accounting and material flow analysis (MFA, see e.g. Eurostat, 2001; Bailey et al., 2004a & 2004b; Sendra et al., 2007). In addition to flows within the system, also imported flows and material inputs and emissions required to produce the imported materials were taken into account. Data on the material use and production were received directly from the companies themselves, from the VAHTI database of the Finnish Environmental Administration, companies' environmental reports, expert estimations, available LCA databases (mainly the Ecoinvent database (www.ecoinvent.ch)) and literature. The calculations were conducted using the KCL-ECO LCA software (Oy Keskuslaboratorio – Centrallaboratorium Ab 2004, the Finnish Pulp and Paper Research Institute).

Results

Direct material inputs to the system amounted to 1,403,500 tons in 2005 (Figure 1). Indirect material flows (i.e. material inputs required in the production of the direct inputs) were about 600,000 tons higher, i.e. 2,026,300 tons. The system produced altogether 773,900 tons products and 15,300 tons solid waste. Emissions to air and water totaled almost 1,500,000 tons. The largest material flows consisted of fuels (particularly diesel, wood-based fuels, coal and crude oil), gravel and wood. Table 1 presents the inputs and outputs in more detail. Direct energy inputs to the system were approximately 340 GWh.

Figure 2. shows each symbiosis' actors' contribution to the total material requirement (TMR) of the system (including material inputs required to produce the raw materials used). The pulp and paper plant is the key actor of the symbiosis and this shows also in its share of the system's TMR. It consumes over 60% of the system's total material requirement. The power plant uses over 25% while the share of the other actors' is considerably lower. Figure 3 features each actors' dependence on the symbiosis' resources. One can see that the calcium carbonate plant and the power plant get the largest share of their resources from the other actors of the symbiosis while the hydrogen peroxide plant and the chlorine dioxide plant are not so dependent on the other actors' of the symbiosis in their supply of resources. However, it should be noted that the chlorine dioxide plant, calcium carbonate plant and the pulp and paper plant all receive a large share or all of their energy supply from the symbiosis.

The eco-efficiency (measured as material product / TMR) is by far the largest at the peroxide plant reflecting its low material intensity (Figure 3). Calcium carbonate plant, pulp and paper plant and the municipal sewage plant have eco-efficiencies a little above the whole system's eco-efficiency.

Conclusions and future studies

In this study, the material flows of an industrial symbiosis centered around a pulp and paper plant were studied. The results show that the largest share (over 60%) of the system's material use was consumed by the pulp and paper plant. The power plant consumed approximately 25% of the system's TMR. The eco-efficiency of the hydrogen peroxide plant was the highest reflecting its low material requirement.

Based on the results we conclude that MFA can provide a good first estimation of the symbiosis' environmental impacts. It gives indication on where the main focus points may be. In order to gain a deeper understanding of the system's environmental impacts, more detailed methods, such as life cycle impact assessment should be used.

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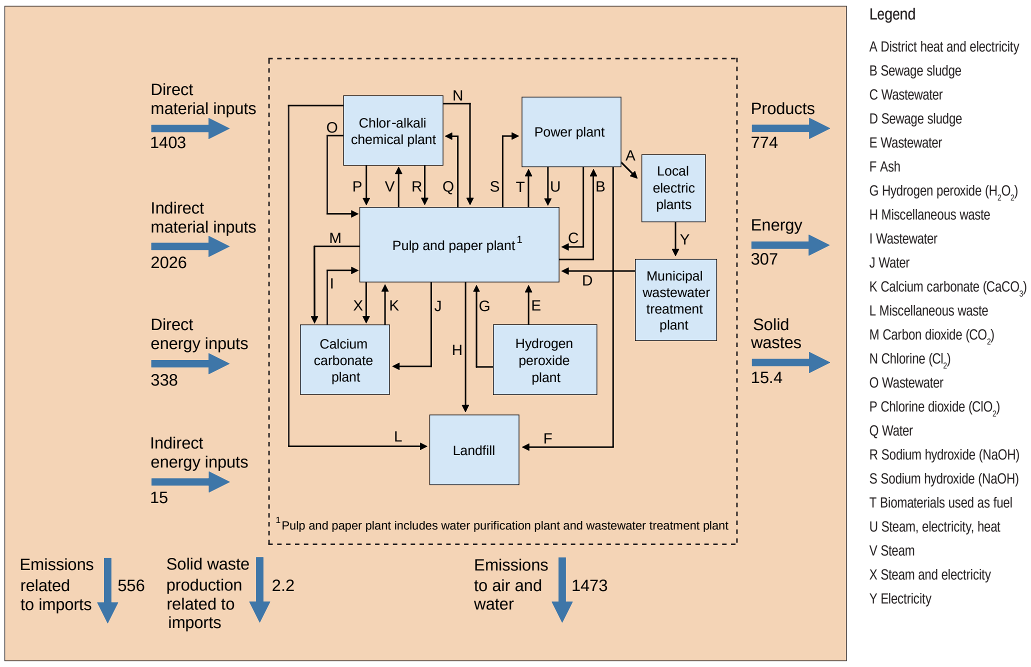

Figure 1. Input and output material (1000 t/year) and energy (GWh/year) flows of the system in 2005. Water use has not been taken into account except for water contained in the products or waste materials.

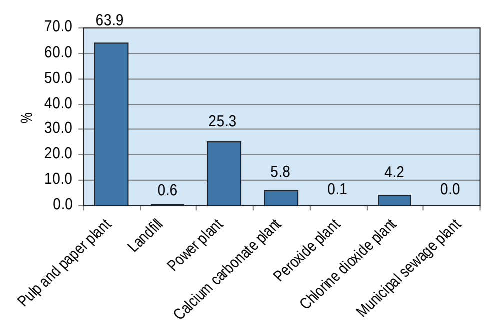

Figure 2. Each actors' contribution (%) to the symbiosis' total material requirement.

	Actors								End use		
Actors	Pulp and paper plant	Landfill	Power plant	Calcium carbonate plant	Peroxide plant	Chlorine dioxide plant	Municipal sewage sludge plant	Total	Exported products	Waste outputs	Total outputs
Pulp and paper plant	-	6800	277200	44900	0	0	0	328900	721400	9200	1059500
Landfill	0	-	0	0	0	0	0	0	0	0	0
Power plant	0	18300	-	0	0		0	18300	0	1030	19300
PCC plant	79400	0	0	-	0	0	0	79400	26500	4400	110300
Peroxide plant	2600	0	0	0	-	0	0	2600	24700	330	27600
Chlorine dioxide plant	40800	70	0	0	0	-	0	40900	1300	10	42200
Municipal sewage plant	2100	0	0	0	0	0	-	2100	0	380	2500
Total use of products from the park	124900	25200	277200	44900	0	0	0	472200	773900	14970	1261400
Imports from outside the system	877500	10	355200	64500	340	105400	380	1403400	-	-	-
Indirect product flows related to imports	1493200	-	356500	118900	4900	56700	230	2026300	-	-	-
Total use	2495600	25200	988900	228300	5300	162100	610	3906000	773900	15400	1261400

Table 1. Detailed input and output material flows of the symbiosis' actors (t/year). The numbers may not add up due to roundings.

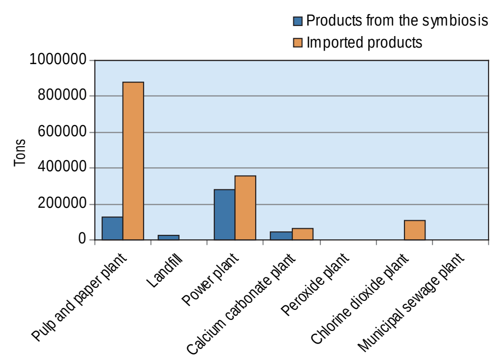

Figure 3. The symbiosis actors' use of imported products and products originating from symbiosis

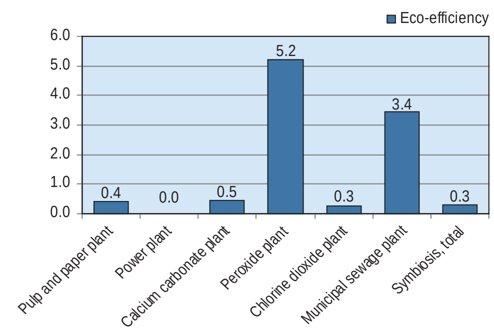

Figure 4. The eco-efficiency of the whole system (measured as material product / TMR) and its individual actors. Power plant's eco-efficiency is not comparable with the others since it only produces electricity and heat, which were not taken into account.




Photos: UPM, photo archive

Graphic design Marja Vierimaa

Phytoplankton succession in various nutrient treatments

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Aim of the study

The aim was to analyze the responses of coastal phytoplankton communities and species to various nutrient treatments. The large data set originating from mesocosm experiments carried out during 6 different years made it possible to study the responses of the species in initially differing biological and environmental conditions.

Methods

The data set included six large-scale mesocosm experiments that were carried out during the years 1988–2003 in south-west coast of Finland, northern Baltic Sea (59º50'N,23º15'E). Salinity in the area is usually 5–6 PSU. In July-August the water temperature is ca. 16–19ºC and phytoplankton community is dominated by filamentous N_2-fixing cyanobacteria (e.g. Niemi 1975, Kangro et. al 2007).

The experiments lasted 14–21 days in July-August. The floating enclosures were 9–15 m deep with volume of 30–50 m^3 (Fig.1). The mesocosms were manipulated with distinct nutrient additions (Table 1). The pelagial community responses within different food-webs have been studied previously from single experiment years by e.g. Kuuppo-Leinikki et. al (1994), Heiskanen et. al (1996), Olsen et. al (2001) and Olli (2004).

In this study the whole data set was analyzed with multivariate analyses to visualize the relationships between nutrient manipulations and phytoplankton species.

Results

The phytoplankton community structure and biomass varied considerably between the experiment years and the manipulations (Fig.2, Fig.3). But also the succession inside single mesocosms was clear during the 14–21 day experiments, which is shown by the length of the arrow representing the experiment day (ExpDay) in cca-graphs (Fig.4). Cyanobacteria *Aphanizomenon* spp. and *Anabanea* spp. were important in each experiment year. Other species forming dense biomasses during the experiments were e.g. euglenophyte *Eutreptiella gymnastica* (Tv93) and dinoflagellate *Heterocapsa triquetra* (Tv96, Tv98). Picoplankton had positive correlation with addition of nitrogen and phosphorus together (NP, NPF), but some negative correlation with the experiment day (ExpDay), while *Heterocapsa triquetra* correlated slightly positively with experiment day. In experiment Tv03 it was shown that N_2-fixing cyanobacteria correlated more with phosphorus addition (P) than with nitrogen addition (N).

Conclusions

- From the used manipulations, nitrogen addition together with phosphorus addition (NP) in Redfield ratio evoked the highest increase in phytoplankton total biomass.
- Picoplankton biomass had positive correlation with addition of both nitrogen and phosphorus together (NP, NPF).
- A dinoflagellate *Heterocapsa triquetra* was one of the species showing highest increase during the experiments and thus also some positive correlation with the experiment day.
- N_2-fixing cyanobacteria correlated positively with phosphorus addition (P).

This study is a part of the EU THRESHOLDS project, which is focused on studying thresholds of environmental sustainability.

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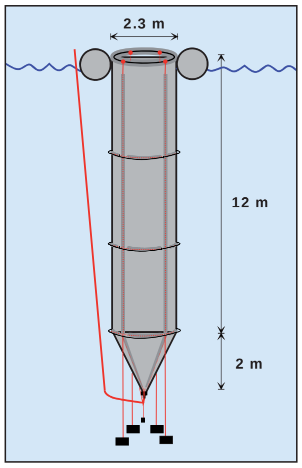

Fig.1. Drawing of a 50 m^3 floating mesocosm.

Tv88 = 1988	Tv92 = 1992	Tv93 = 1993	Tv96 = 1996	Tv96 = 1998	Tv03 = 2003
4 periods: *Bag1. -; NP; F; NPF Bag2. NP; -; NPF; F Bag.3. F; NPF; -; NP Bag4. NPF; F; NP; - Bag5. - "Bag6." Sea (N=Nitrogen, P=Phosphorus F=Fish)*	*Bag1. – Bag2. NP Bag3. Fish Bag4. NP+Fish Bag5. C Bag6. NPC "Bag7" Sea (C=Carbon)*	*Bag1. – Bag2. NP Bag3. NP Bag4. NP Bag5. Fish Bag6. NP+Fish Bag7. C Bag8. NPC*	*Bag1. – Bag2. NP Bag3. NP+ Bag4. NP++ Bag5. NP+++ Bag6. NP++++ Bag7. NP+++++ Bag8. NP++++++*	1.Week: *All bags:N+P* 2.-3.weeks: *Bag1. – Bag2. N:P 16++ Bag3. N:P 16+++ Bag4. N:P 6+ Bag5. N:P 6++ Bag6. N:P 40++ Bag7. N:P 40+++ Bag8. N:P 16+++*	1.Week: *All bags:N+P* 2.-3.weeks: *Bag1.NP Bag2. N Bag3. P Bag4. 5*N Bag5. 5*P Bag6. 5*N+C Bag7. 5*P+C Bag8. NPC "Bag9" Sea*
Daily addition *during the 4 periods: 4u µg/L PO4 16 µg/L NH4 Fish= 90 stickelbacs*	2 pulses *on days 0 & 6: 15µg/L PO4 30µ/L NH4 30µg/L NO3 400µ/L SucrC* At start: *210sticklebacks*	3 pulses *on days 0,7&14: 15µg/L PO4 30µg/L NH4 30µg/L NO3 400µg/L SucrC* At start: *400sticklebacks*	Daily addition *N:Si:P=16:16:1 in molar ratios (Redfield). N-add. linearly: 0; 0,14; 0,44; 0,59; 0,74; 0,88; 1,03 µmol/L N*	Daily addition *N:P ratio in bags 1-8 : natural; 16; 16; 6; 6; 40; 40; 16 N-add. linearly in bags1-8: 0; 0,29; 0,73; 0,12; 0,29; 0,29; 0,73; 0,73 µmol/L N*	Daily addition: *N=1 µmol/L P=1/16 µmol/L C=13,25µmol/L*

Table 1. Manipulations of different mesocosms (=bags) in all experiment years (1988, 1992, 1993, 1996, 1996, 1998, 2003). N=Nitrogen addition, P=Phosphorus addition, C=Carbon addition, F=Fish present, – = No additions, Sea=open sea samples.

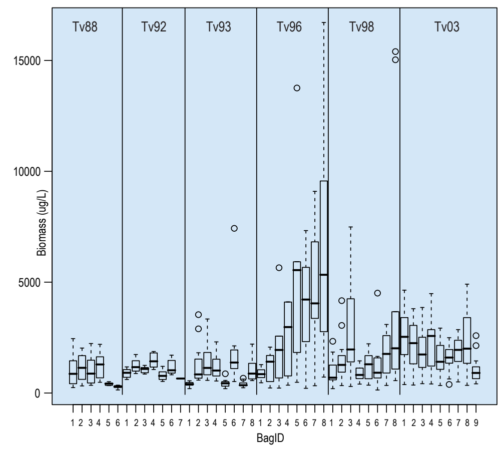

Fig. 2. Total phytoplankton biomass (ww) varied notably between the experiments and the treatments. The variation inside one bar represents the variation of total phytoplankton biomass during the experiment inside a single mesocosm. As expected, nutrient additions increased the biomass towards the end of the experiments. The total phytoplankton biomass responded strongest in the experiment Tv96, in which nitrogen was added in linearly increasing concentrations (N:P in Redfield ratio, see Table 1).

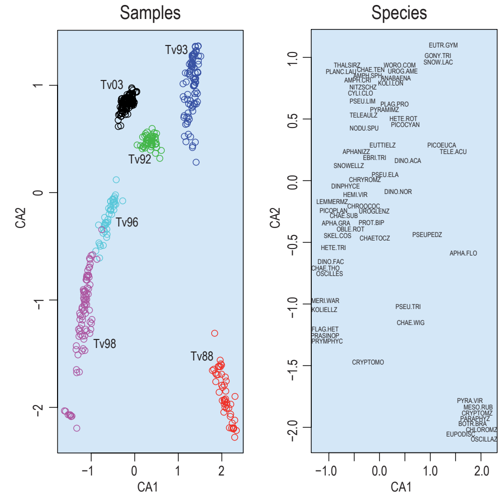

Fig.3. Correspondence Analysis (CA) of the whole data set. The left panel visualizes the difference between all samples based on phytoplankton communities. Samples that are most similar, are situated closer to each other. The clearest separator for the samples seems to be the experiment year. The right panel shows the phytoplankton species that characterize these samples best. For example Tv93 was characterized by e.g. species Eutreptiella gymnastica, Snowella spp. and Gonyaulax triquetra.

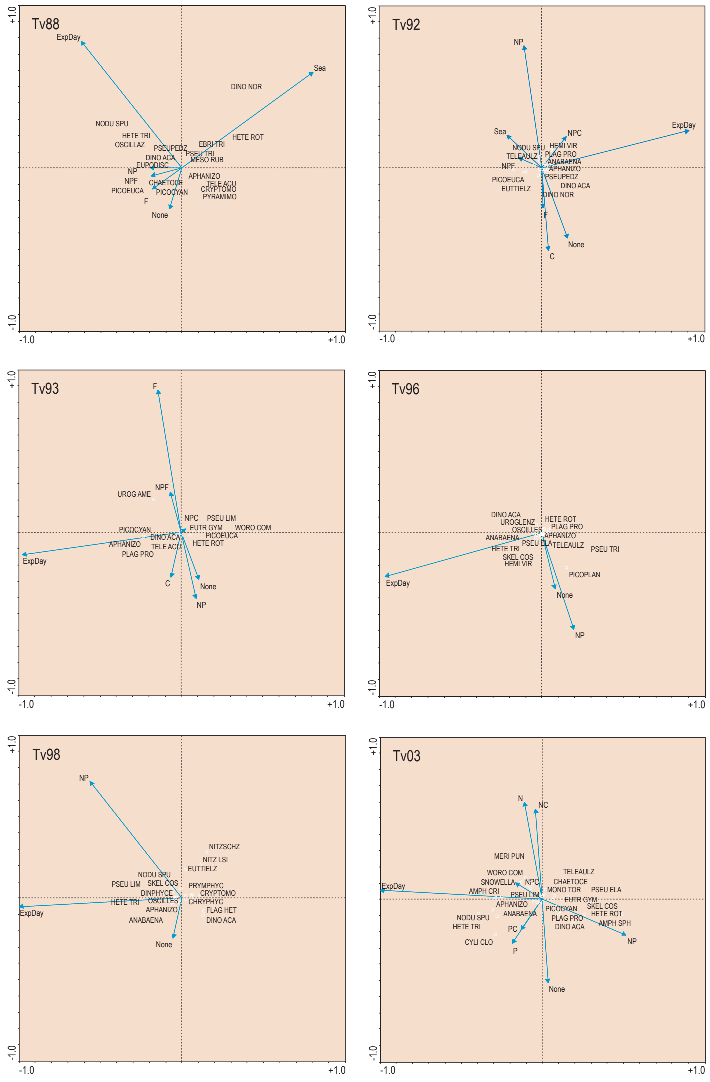

Fig. 4. Results of Canonical Correspondence Analysis (CCA) for each experiment year showing the responds of phytoplankton species to differing manipulations during the experiments. The length of the arrow expresses the importance of the variable. Species situated near the arrowheads correlate most positive with the variable.

ExpDay=Experiment day. Additions used in manipulations: N=Nitrogen, P=Phosphorus, NP=Nitrogen and phosphorus together, C=Carbon, NC=Nitrogen and carbon, PC=Phosphorus and carbon, NPC=Nitrogen, phosphorus and carbon, F=Fish, NPF=Phosphorus, nitrogen and fish, None=No additions, Sea=Sea sample. Species e.g. CHRYPHYC=Chrysophyceae spp., CRYPTOMO=Cryptomonadales, DINO ACA=Dinophysis acuminata, DINPHYCE=Dinophyceae spp., DINO NOR=Dinophysis norvegica, EUTR GYM=Eutreptiella gymnastica, EUTTIELZ=Eutreptiella spp., FLAG HET=Heterotrophic nanoflagellates, HETE TRI=Heterocapsa triquetra, NITZSCHZ=Nitzschia spp., Nodu spu=Nodularia spumigena, OSCILLES=Oscillatoriales spp., PICOCYAN=Picocyanobacteria, PICOEUCA=Picoeucaryotes, PICOPLAN=Picoplankton, PLAG PRO=Plagioselmis prolonga, PSEU ELA=Pseudopedinella elastica, PSEU LIM=Pseudanabaena limnetica, PRYMPHYC=Prymnesiophyceae spp., PYRAMIMO=Pyramimonas spp., SKEL COS=Skeletonema costatum, TELEAULZ=Teleaulax spp., TELE ACU=Teleaulax acuta, UROGLENZ=Uroglena spp., WORO COM=Woronichinia compacta.

The Benefits of TBT Removal

The Vantaa River – Port of Helsinki Case Study

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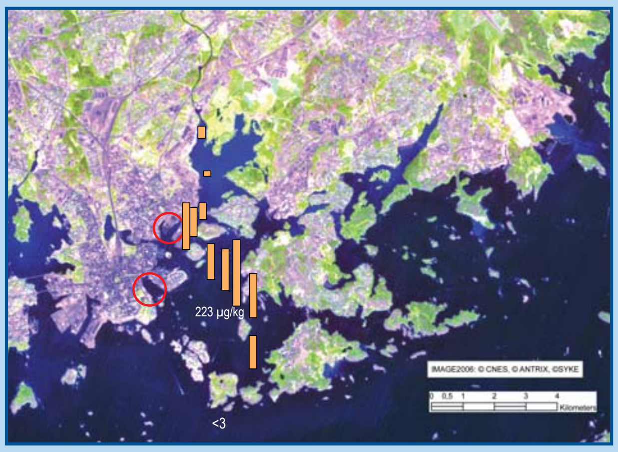
Introduction/problem

- Non compliance of TBT with the Water Framework Directive EQS is anticipated from the sediment concentrations and from the measurements of the water above the sediment surface
- Fish in the area are contaminated with TBT and TPhT
- Primary source is the former use of TBT in antifouling paints and subsequent leaching, dissolution and mechanical scrapping of paints from ships
- The area includes several recreational ship and boat harbors and small wrecks and two main ports for trader shipping and passenger traffic



Concentrations of TBT in surface sediment (µg/kg d.w.). (Vatanen 2005)
= Main ports

Conclusions

Comparison of costs with benefits does not support dredging as a remediation method in the Helsinki Kruunuvuorenselkä area. However, people's willingness to pay was not tested.

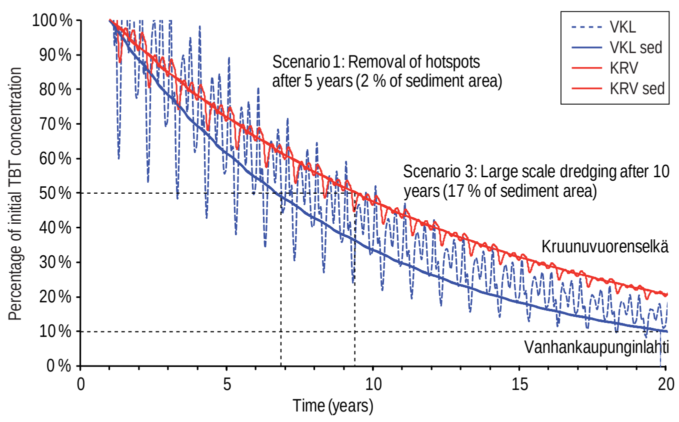
The project was financially supported by EU (Project contract no. 037038).

Baseline scenario

- The use of TBT in small ships was banned in Finland in 1991 and in large ships from 2003 onwards, which consequently already decreased the emissions from these sources.
- Over painting or total removal of TBT containing paints became mandatory from the beginning of 2008.
- A major change took place, when the port for trader shipping at Sörnäinen northern main port was closed in November 2008

Modeling the baseline scenario for TBT

- Based on the mass balances of organic carbon and water, a dynamic mass balance for TBT was constructed (transport equations from the POPCYCLING Baltic model of Wania et al. 2000).
- Emission of 20 kg/a to the water column of Kruunuvuorenselkä was simulated, resulting in a steady state concentrations of 150 µg/kg d.w. in sediment, which is close to the observed mean concentration.
- This corresponds to 8 ng/l in the water column (40 times the EQS), which is at the range of the few measured analyses of TBT from water (<1 ng/L to 12 ng/L).
- This "load" was used as a starting point for the baseline scenario and emissions were set to zero
- One year after the cessation of emissions, sediment concentrations would be practically the same, but the water column concentrations would have decreased to 0.1 µg/l (i.e. 50 % of the EQS).
- Major uncertainty in model calculation is the degradation rate of TBT in the oxic water/sediment interface.



Recovery of the surface sediments (0–7 cm) after the cessation of the emissions. Lines depict concentrations in two areas VKL (Vanhankaupunginlahti) and KRV (Kruunuvuorenselkä) and in two media: sediment and water column. One year after the cessation was chosen as the base year and the percentages are calculated on that basis. Halving of concentrations is predicted to take approximately 7–10 years. NOTE: Practically no decrease in anoxic deep sediment layers.

Dredging options and costs

After consultation with the local stakeholder group three different dredging options with different sediment locations and velocities were evaluated.

Three dredging scenarios

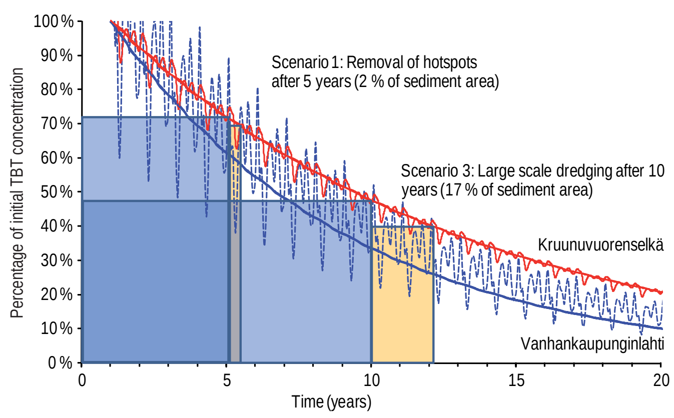
1. Hot spot removal (areas with TBT concentration > 200 µg/kg (dw), disposal only on land.
2. Shipping routes (disposal on land and in sea)
3. Maximum possible dredging (disposal on land and in sea)

	1. scenario	2. scenario	3. scenario
Dredged mass m^3	100 000	500 000	1 000 000
Dredging depth m	0.4	0.4	0.4
Dredged area ha	25	125	250
Average TBT concentration of the dredged sediment µg/kg (dw)	200	150	150
Amount of removed TBT kg	13	49	98

Costs of different scenarios presented as net present values was based on nearby case (Vuosaari port) and an assessment report (BATman) and evaluated per kg of TBT.

	Ref. Op. 1	BatMan Op. 1	Ref Op. 2	BatMan Op. 2	Ref Op. 3	BatMan Op. 3
M€/TBT kg	0.49	0.57	0.24	0.36	0.22	0.35
i 2 %	0.49	0.57	0.23	0.36	0.21	0.34
i 3 %	0.49	0.57	0.23	0.35	0.21	0.33
i 5 %	**0.49**	**0.57**	**0.22**	**0.34**	**0.20**	**0.32**

Benefits



The effects of dredging scenarios and the predicted natural attenuation of sediments from TBT in Kruunuvuorenselkä and Vanhankaupunginlahti. The solid lines are concentrations in sediment and the dotted lines are in the water column.

- The modeling indicated that with the expected natural attenuation rate an equivalent amount of TBT is decomposed in the surface sediment within half a year than would be removed in the first scenario.
- In practice the effects of dredging to decrease the water concentration is expected to take even longer than the natural attenuation, because of increased sediment resuspension during the operations.

Other benefits from dredging?

- Benefits for the fishermen and recreational fishing due to less TBT contaminated fish are uncertain because of possible effects during dredging operations
- Some benefits gained from dredging can not be attained by other measures, e.g. removal of other hazardous substances (heavy metals, POPs)
- The indirect benefits may be recreational and economical and could also reduce health hazards.

Graphic design Marja Vierimaa