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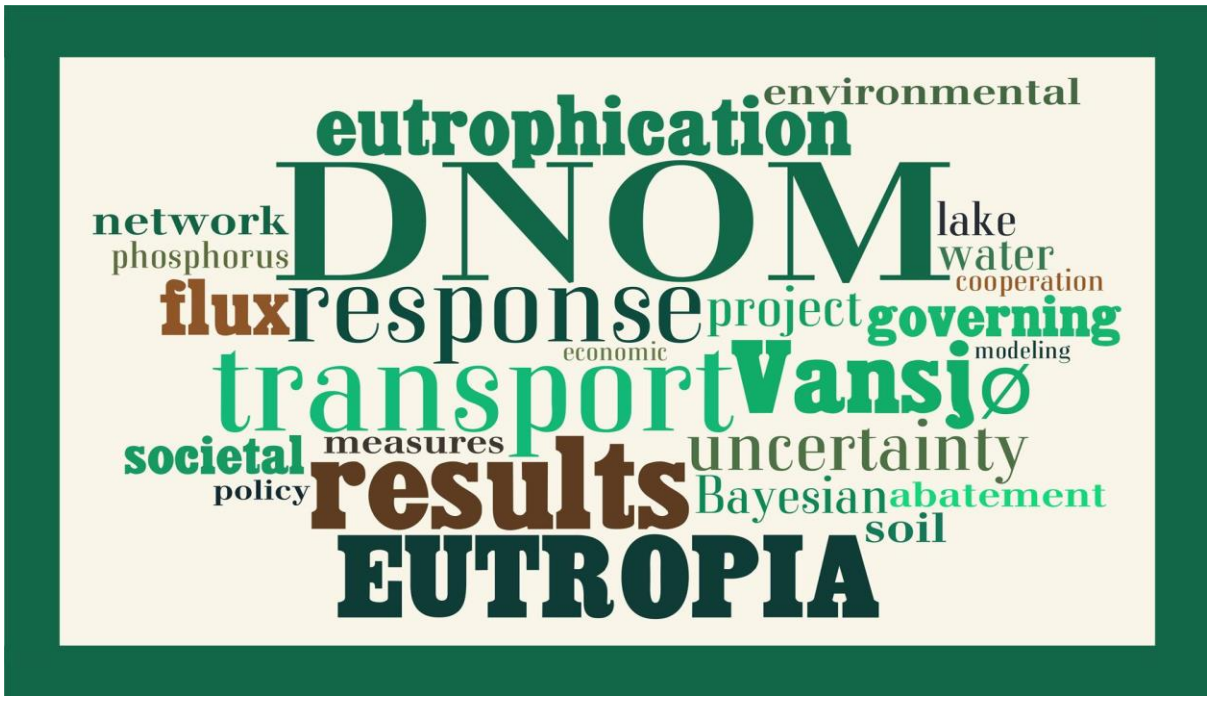
BOOK OF ABSTRACTS

Final EUTROPIA Conference Conference 2012:

Creating a common understanding of the factors that influence the environmental conditions of our water bodies

30 – 31 May 2013, CIENS Toppsenter, Forskningsparken



Societal Response

The Morsa River Basin: An example of multi-level water governance

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Management of fresh water resources meets a range of often conflicting interests. Waterways usually run across political and administrative borders and hence make management more difficult and politically challenging. In order to meet these challenges integrated bioregional approaches to water management have been called for. Such an approach is institutionalized in EU's Water Framework Directive (WFD). This presentation will discuss the experiences of the management of the Morsa catchment as an example of multi-level network governance. The Morsa project started on a voluntary basis in 1999 and was integrated in the Norwegian programme for implementation of the WFD in 2005. I shall present the experiences from Morsa in the light of four principles for multi-level water governance: polycentric governance, public participation, an experimental approach and management on a bioregional scale. The analysis concludes that a key to understanding the success of Morsa is the way in which the Morsa network is linked to the Norwegian system of local and central government and the importance of an active leadership.

Farmers' rationality, and learning and knowledge among farmers

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Geir's presentation will be based upon two articles, whose abstracts are as follows:

1. *The Rational Economic Man as a basis for doing environmentally sound farming: fact or fiction?*
2. *Trans-disciplinaryily required in understanding, prediction and dealing with water eutrophication*

The Rational Economic Man as a basis for doing environmentally sound farming: fact or fiction?

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This article discusses the relevance of Rational Economic Man, neoclassical economics, neo-liberal theories and policy-making for analyzing farmers' practices and actions for avoiding leaching of phosphorus to water courses in a Norwegian watershed. Theories claiming farmers to be pursuing solely economic self-interest and maximizing are criticized. Based on in-depth interviews with farmers in the watershed, the interaction between different factors underlying farmers' motives and practices is analyzed: e.g. economics; competence in farming; learning and knowledge; interactions among farmers; interactions between farmers and local communities and wider society; fairness and justice regarding contributions by farmers and others; and perceived reasonability of policy regulations and policy measures. The analysis shows that rigid regulations causing a lot of hassle for the production, and also with considerable negative economic consequences, might backfire and undermine farmers motivations for doing other actions that isolated are considered reasonable

Trans-disciplinarily required in understanding, predicting and dealing with water eutrophication

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Eutrophication remains a challenge for water quality, and although point source emissions of sewage are mainly under control leaching of nutrients from agriculture becomes the determining factor. The watershed Morsa southeast of Oslo is a case in point. In spite of abatement actions taken over the last 10 to 15 years, the improvements have been slower and much smaller than expected, also causing growing frustration and scepticism among farmers. Hydro-biochemical interactions between phosphate and calcium, aluminium and iron in soil and water have produces unexpected results. Reducing acid rain over Norway has reduced the leaching of aluminium into water and less of the phosphorus in the lake has been bound to aluminium, thereby increasing the stock of bio-available phosphorus. The combination of higher precipitation and higher temperatures causes more flushing out of phosphorus from forested area. In soil saturated by water iron is transformed and interacting with sulphate and sulphide, thereby allowing more orthophosphate to escape and possibly causing elevated concentration of bio-available phosphate. The farmers proved to have a good agronomical knowledge, and taking part in an active network for spreading of agricultural practices. Reducing the amount of phosphorus in fertilizers was accepted fairly quickly, whereas minimal autumn tillage has been a much harder task to accomplish. Therefore, just economics will not do; developing basic environmental literacy is necessary, with an ability to understand feedback loops and rebound effects. Following this, also the interaction between science and stakeholders is important, and it is necessary to engage in trans-disciplinary research and trans-disciplinary processes.

Modelling of catchment and lake processes

Evaluation of agricultural best management practices in the Western Vansjø catchment using a probabilistic modelling approach

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The effect of agricultural abatement actions are modeled using a probabilistic approach with the Soil and Water Assessment Tool (SWAT) in the catchment of Western Vansjø in south-eastern Norway as a part of the EUTROPIA project (RCN 190028). Estimating the effects of agricultural best management practices (BMPs) on water quality often leads to reliance upon some form of modelling. However, all models carry inherent uncertainties. These uncertainties are related to uncertainties in input data, parameter values, process simplifications, processes not accounted for by the model, and processes in the watershed that are unknown to the modeler. Model uncertainties are important to address to obtain a reliable framework for decision making.

In this study uncertainties are quantified by the use of the SUFI2 (sequential uncertainty fitting ver. 2) algorithm. By this method we produce a distribution of run-off scenarios which may be deemed equally probable, instead of one deterministic situation that does not account for these uncertainties.

The model was first calibrated against observed data and management measures in the Guthus sub-catchment for the years 2006-2010. Forecasting of a series of management measure scenarios was then preformed including phosphorus fertilization, implementation of vegetated buffer zones along streams, implementation of constructed wetlands (CW), changes in autumn plowing, land use changes, removal of point sources or combinations of these. The model was also used to carry out hindcasting, notably the current state of the lake without management measures that were actually implemented during the past decade. Results show that incremental abatement actions implemented in only parts of the agricultural catchment have very little effect on P-loading, while BMP combinations performed on 100% of the agricultural area reduced P-loading significantly.

How simple should lake eutrophication models be?

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In 1969, R. E. Vollenweider introduced a simple box model that would become the cornerstone of science-based eutrophication abatement. The model represents the phosphorus mass balance of a lake in terms of a single, quantifiable parameter – the phosphorus retention coefficient. Since it lumps all processes of the phosphorus cycle into a single parameter, the simplicity of this model also severely limits its sensitivity and predictive power, because there many different processes contributing simultaneously to the retention and burial of phosphorus in the lake sediments. The problem with improving and extending the Vollenweider model thus becomes the same as with all modelling: – which processes are the important ones, and which can be ignored or simplified without loss of predictive power? The answer to this question obviously needs to take into account the level of scientific understanding of different processes, which will typically decease when going from physical to chemical to biological processes. The phosphorus retention in a lake can be decomposed into processes involving the partitioning of phosphorus between water and particles, the sinking and re-suspension of particles, the biogeochemical processes on particle surfaces, and the acquisition and utilization of phosphorus by biota. I will present some current development trends in lake modelling, and try to characterize them according to which processes they focus on and what predictive capabilities these modifications entail.

How to make friends with environmental models: three points of view

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The interdisciplinary project EUTROPIA combines several research fields from social and natural sciences for abating eutrophication. Environmental modelling is one of the involving research fields, and the importance of its role in the project is as great as socioeconomic, agricultural, and chemical analyses, to name a few. Here, I propose a typology of various aims placed on environmental modelling. One is scientists' perspective. Scientists are the source of base knowledge, and scientists might for example be concerned with how to simplify the vast amount of knowledge, before providing it to environmental models. The second type is modelers' perspective. Modelers tend to be concerned with technical details of the art of environmental modelling, including problems arising only on the numerical level. They may also be interested in studying methods for training the models, or elucidating uncertainties or risks in prediction. The last type I identify is the managerial perspective. In EUTROPIA, models are expected to have predictive ability under several hypothetical management scenarios. In other words, models extend empirically based scientific knowledge to a forecast. In reality, these three perspectives are deeply interconnected and not mutually exclusive; scientists, modelers, and managers are all aware of these perspectives. I discuss these perspectives from my own experiences using modelling results of EUTROPIA. What would you say if you were one of the deployed models?

Economic modelling of nonpoint source pollution

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The starting premise for the economic analysis is that farmers select crop rotations and tillage practices that maximize their expected profits. Current practices are however constrained by several factors, where available labor (including the tradeoffs between farm and off-farm work), and crop rotations to avoid loss in product quality are the most important.

A potato-spring wheat-cabbage rotation is used as a proxy for current practices to limit the number of simulations. Changes in leached phosphorus and erosion are then calculated for various crop rotation and tillage scenarios. While there is substantial variation in leached phosphorus and erosion between years, main results are fairly robust:

- A switch from fall to spring tillage in grains reduces phosphorus leakages and erosion substantially without reducing farm profits to a noticeable degree.
- A switch in fertilization regimes for grains reduces Phosphorus leakages, but has limited impacts on farm level profits.
- Reductions in the acreage of cabbage and potatoes lead to further reductions in leakages, but have severe implications for farm profits.

These results are used to provide a framework for calculating mean private costs for abatement measures, and to suggest the magnitude of emission taxes or compensation payments for voluntary adoption of agricultural practices that cause less Phosphorus leaching and erosion.

The current analysis is conducted at the watershed level, and does not capture retention of Phosphorus and soil particles from farm fields with varying distance to the Vansjø lake. Further analyzes will be undertaken to estimate these effects.

Abatement actions and uncertainty analysis

A tool for communicating confidence in predictions of nutrient abatement effectiveness

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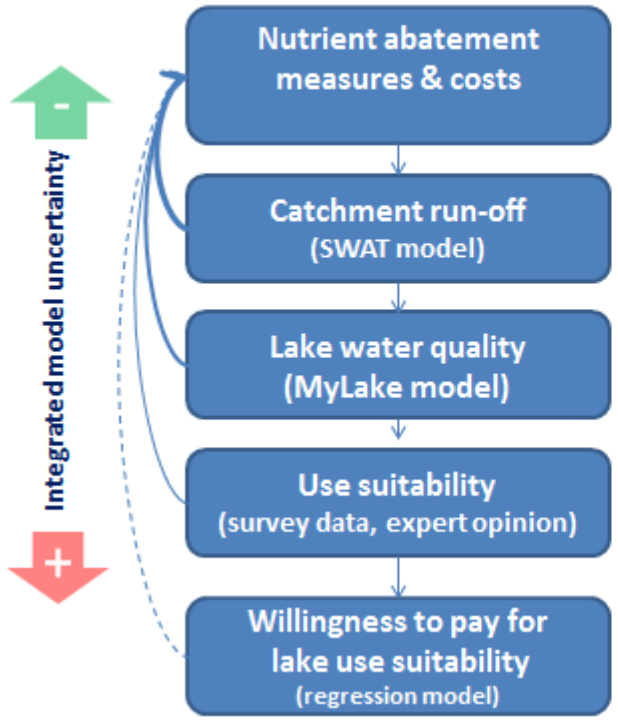
This presentation provides an illustration of the use of causal probabilistic network models in communicating the uncertainty regarding the effectiveness of abatement measures.

A probabilistic causal network is used to explore the interdependence of a series of domain-specific models of eutrophication in an already eutrophic watershed in Norway. We use Bayesian network software Hugin Expert to summarise the results of simulation analysis conducted in the catchment model SWAT , the lake model MyLake, expert judgement of use suitability classifications and a survey data on use suitability.

We discuss how Bayesian causal probabilistic network can be used as 'meta-model' of the driver-pressure-state-impact-response of eutrophication spanning different temporal and spatial resolutions of the sub-models (Figure 1). We also demonstrate how integrated model uncertainty increases in the DPSIR causal chain. The presentation discusses the potential and constraints of using integrated uncertainty analysis in the evaluation of programmes of measures under the Water Framework Directive[1].

References:

[1] Presentation by Jannicke Moe (*Bayesian networks for assessment of WFD compliance based on lake phytoplankton)*.



	Temporal resolution	Spatial resolution
Response/ Driver	Annual	Farm
Pressure	Daily	Catchment
State	Daily	Lake (vertical)
Impact	Seasonal (summer)	Lakeshore
Impact/ Response	Annual	Household location around lake

Figure 1. Our systems modelling approach involved linking a series of different model domains together in a Bayesian causal probabilistic network. This 'meta-model' of the driver-pressure-state-impact-response of eutrophication in the Vanemfjorden spanned different temporal and spatial resolutions of the sub-models. How the integrated model uncertainty increases in this causal chain is studied. The systems approach also comprised an evaluation of stakeholder environmental literacy regarding different nutrient abatement measures, their costs and effects. A challenge for our systems modelling approach lies in the confrontation of stakeholder knowledge with the uncertainty of the system described by the researcher. We therefore evaluated how scientific knowledge gained from

Bayesian networks for assessment of WFD compliance based on lake phytoplankton

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Norwegian water management aims at achieving good ecological status for all water bodies. The Water Framework Directive (WFD) states that assessment of ecological status should primarily be based on biological quality elements, such as phytoplankton (algae) in lakes. Moreover, according to the Norwegian ecological classification system, phytoplankton should be assessed both by total biomass (chlorophyll-a) and by the amount of cyanobacteria (potentially harmful algae).

We therefore investigated the effects of various abatement actions for nutrient reduction on the probability of obtaining good ecological status in Lake Vansjø (Vanemfjorden), by assessment of phytoplankton (both chl-a and cyanobacteria) as well as supporting physico-chemical elements (Secchi depth and total phosphorus). A Bayesian Network (BN) model was developed for analysing effects of 5 different abatement actions in altogether 15 combinations. A BN is composed of discrete probability distributions, which enables linking different types of information. The first part of the BN is based on output from process-based models predicting effects of the abatement actions on physico-chemistry in the catchment (SWAT) and in the lake (MyLake) over 20 years. The second part links these model predictions to the observed phytoplankton time series from the same period (from NIVA's AquaMonitor database). The third part links the phytoplankton indices to the Norwegian classification system, predicting the probability of different status classes. We aim at assessing (1) the effects of the different management combinations on the ecological status, (2) the impacts of uncertainty from different model components and (3) the suitability of the BN approach for this purpose

Pressures and their mechanisms governing loading of P fractions

Reduction in acid rain and climate change disguising abatement effects

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High phosphorous (P) loading is usually the main cause for cultural eutrophication of freshwaters. Abatement actions targeting Total P loading often fail to restore good ecological quality. This is partly due to concurrent local (land-use change, increased use of drainage pipes), regional (acid rain) and global (climate) changes in drivers of P flux in the environment that lead to an concomitant increased 'background' loading of P to surface waters, and loss of an important P removal mechanism. Moreover, climate change is altering the basis for what might be termed the natural background condition. We must therefore understand conceptually the hydro-biogeochemical processes governing the leaching and transport of different P fractions in order to evaluate the effects of these changes in the environment.

Total-P in water is analytically divided into 3 fractions: P bound to particles (Particulate-P), Dissolved Organic Matter bound P (DOM-P) and Bioavailable-P. The amount of Total-P is predominantly governed by the Particulate-P, and varies mainly according to extension of agricultural land-use and -practices in the watershed, erosion risk as well as runoff intensity. The other P fractions may nevertheless be of greater importance for the eutrophication of lakes since Particulate-P is not bioavailable. Instead it readily settles and is buried in lake sediments.

Over the past 30 years decreased acid rain has contributed to doubling of dissolved organic (mainly humic) matter (DOM) concentrations while inorganic labile aluminium (Al_i) is reduced to a third in streams draining acid sensitive forests in the study region. Increased DOM inherently carries increased background flux of DOM-P. Moreover, during the acid rain epoch the Al_i efficiently precipitated bioavailable P where the runoff mixed with drainage from agricultural areas with circum neutral pH and high P concentrations.

Impact of DNOM photo-degredation on its bioavailability in freshwater lakes

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The slow amelioration in the eutrophic status at lake Vansjø, south-eastern Norway, despite numerous abatement actions to reduce the nutrient input from agricultural sites in the catchment, has brought focus to the role of background phosphorus (P) nutrient input. This flux of P is mainly associated to dissolved natural organic matter (DNOM) which accounts for approx. 40% of the total P loading to the lake[1]. With 85% of the catchment being forested area leaching high concentrations of DNOM, and with a doubling of the concentration of DNOM over the last 20 years[2, 3], particular focus has been brought onto the bioavailability of DNOM derived P. For this reason much focus is directed toward photo-degradation in the lake, which alters the DNOM and can potentially release phosphate making it bioavailable. A variety of laboratory experiments using artificial sunlight (Q-Sun Xenon Test Chamber) to expose highly humic stream water and a lake study deploying passive samplers for orthophosphate have resulted in varying and contradictory results leading only to more uncertainty regarding the effects of photo-degradation on the bioavailability of P.

In addition to these experiments regarding the fate of P, the effect of sunlight on DNOM bioavailability was analyzed through a combined photo-degradation incubation experiment. Changes in DNOM concentrations and characteristics during the photo-oxidation and pre- and post- incubation were measured by use of UV-VIS and fluorescence spectroscopy, TOC analyzer, and pH.

References:

[1] Blankenberg, A., S. Turtumøygard, A. Pengerud, H. Borch, E. Skarbøvik, L. Øyegarden, M. Bechmann, N. Syversen and N. Vagstad. 2008. *Tiltaksanalyse for Morsa: Effekter av fosforreduserende tiltak i Morsa 2000 – 2006.* Bioforsk, Jord og Miljø, Ås, Norway.

[2] NORDTEST. 2003*. Increase in colour and amount of organic matter in surface waters*, The Nordic Council of Ministers.

[3] Skjelkvåle, B.L. 2010. Overvåkning av langtransporterte forurensinger. ISBN 978-82-577-5721-2, Klima- og Forurensningsdirektoratet (Eng. Climate and Pollution Agency).

By breaking down conjugated double-bonds, photo-degradation transforms colored refractory DNOM to more biodegradable forms. UV-VIS spectroscopy revealed a loss of absorbance (pre- and post-incubation) in the visible range wavelength (400 to 450 nm), demonstrating this photo-bleaching effect. With short-term photo-exposure (four hours or less), UV absorption increased during post-incubation, indicating an enrichment of aromatic compounds during the biodegradation incubation. The samples exposed to sunlight for 12 hours or more had similar UV absorption pre- and post-incubation. This may suggest that aromatic compounds are relatively stable against photo- and biodegradation, as demonstrated by Kalbitz et al[4]. Collective assessments of changes in absorbency, as well as fluorescence, seem to indicate that humic acids (HA) are broken down into fulvic acids (FA), which have lower molecular weight and thus are more soluble and bioavailable[5].

[4] Kalbitz, K., J. Schmerwitz, D. Schwesig, E. Matzner, 2003. *Biodegradation of soil-derived dissolved organic matter as related to its properties*. Geoderma 113, 273–291.

[5] Maier, R. M., I. L. Pepper, C. P. Gerba. 2009. Environmental microbiology. Amsterdam, Academic Press.

Advances in phosphorus analysis

Advances in phosphorus fractionation methods in water: Development of a new CNP nutrient analyzer, and sampling of low molecular weight organic P and inorganic phosphates by DGT samplers

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WP1 of the EUTROPIA project focused on two areas:

1) Development of a new configuration of an automatic air segmented continuous flow analyzer (CFA) for determination of CNP-nutrients with focus on P
2) New samplers for dissolved inorganic and low molecular weight organic compounds by DGTs.

The focus for the CNP analyzer was efficient analytical methods for the P fractions Tot-P and PO4-P (where organic and particulate P fractions can be estimated by difference). Furthermore, other C and N nutrients can be determined (TOC, TOT-N, NO3-N, NH4-N etc.). Using the CNP analyzer it is possible to separate and determine new fractions of dissolved and particulate P compounds in water as well as those derived from N and C.

We studied the use of DGT samplers (Diffusive Gradients in Thin Films) for collection of inorganic and low molecular weight dissolved P compounds in water. Two new DGT adsorbents were examined for this purpose: Ferrihydrite (Iron hydroxide based) and Metsorb (TiO2(OH) based). Both showed promising properties for sampling of these P compounds in water.

Future Steps

The REFRESH Project: Modelling's possible futures in the Hobøl river with the INCA-P Model

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The Vansjø-Hobøl catchment (SE Norway) comprises several small rivers and lakes, and one large lake (Vansjø) which is divided into two major basins: the Storefjorden and the Vanemfjorden. The total catchment area is 690 km^2, with land use dominated by agriculture (16%) and forestry (80%). The Hobøl river, which is the main tributary of Lake Vansjø, covers 337 km^2 of the total catchment area. Lake Vansjø receives high nutrient loads from its surrounding catchment. This is especially evident in the western basin, Vanemfjorden, which has experienced recurrent blooms of toxin-producing cyanobacteria. In this study, we have linked a hydrochemical river model (INCA-P) with a physically-based lake model (MyLake). We have simulated the current and possible future dynamics of the river-lake system with regard to riverine phosphorus loads and chlorophyll a development in the lakes. Both models were automatically calibrated using an MCMC-DREAM algorithm, which includes parametric uncertainty. Following calibration, the linked models were applied as a platform for simulating the environmental implications of four different scenarios/storylines constituting two management regimes (regulated and non-regulated) in combination with two climate regimes (present and future). The scenario analyses indicate that land use and management regimes together have a stronger impact on water quality than the projected climate change. Even under the best case scenario for land use, management and the evolution of climate, the linked models suggest that it is difficult to reach compliance with the environmental targets set for Lake Vanemfjorden under EU's Water Framework Directive.

Watershed Eutrophication management in China through system oriented process modelling of pressure, impacts and abatement

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Impact assessment of changes in environmental pressures requires conceptual system and process understanding in order to reach the knowledge level relevant for sustainable water resource management. This requires a catchment-oriented approach to integrate processes. The Yuqiao reservoir is thoroughly studied site with long data records. Using a DPSIR approach on its eutrophication problem we set out to design and conduct coherent and synoptic field monitoring and survey of fluxes of nutrient fractions, thereby laying the basis for an assessment of catchment hydro-biogeochemical processes governing mobilisation, transport, and fate of different fractions of phosphorus. In the process of this speech, related concepts will be introduced. Meanwhile, recent lab analysis results of soil and water also will be shared with.