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Managing Nitrogen and Phosphorus Loads to Water Bodies: Characterisation and Solutions

Towards Macro-Regional Integrated Nutrient Management

JRC-Ispra, 14-15 July 2014

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Workshop Background Report
Managing Nitrogen and Phosphorus Loads to Water Bodies: Characterisation and Solutions

Towards Macro-Regional Integrated Nutrient Management

Under Enlargement and Integration Action

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1. Introduction

Nitrogen (N) and phosphorous (P) from agricultural and urban areas contribute to water quality degradation in many EU and Enlargement and Integration[1] countries. Not only inland water bodies, but also coastal waters and bays in surrounding European seas have been degraded by nutrient pollution. These increasing nutrient loads may cause eutrophication eventually adversely impacting the coastal or marine ecosystems by massive blooms of algae.

The EU has set up a number of policy instruments for protecting inland, transitional and coastal waters. The Nitrates Directive intends to protect water resources against nitrates from agriculture sources, and the Urban Waste Water Treatment Directive (UWWT) aims at controlling emissions of nitrogen and phosphorus from point sources. They are both supporting the achievement of the 2015 Water Framework Directive (WFD) objectives of Good Ecological Status for inland water bodies in the EU and those of Good Environmental Status of European regional seas planned by the Marine Strategy Framework Directive for 2020. This legislation is further complemented by national and international initiatives, e.g. the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM), the Convention on the Protection of the Black Sea (Bucharest Convention) and the Convention for the Protection of the Mediterranean Sea (Barcelona Convention), which aim at controlling pollution from land-based sources and maritime transport.

It is against this background that the Joint Research Centre organized a workshop bringing together scientists, policy makers and water managers[2] to exchange experiences on the approaches presently used in Enlargement and Integration countries and in EU 28 Member States in controlling nitrogen and phosphorus emissions from human land-based activities. The Workshop intended to progress from characterisation to solutions linking European and country scales (where decision making takes place) to the watershed and farm scales (where implementation happens). It also addressed the need of a macro-regional approach to nutrient management, as nutrient pollution often goes beyond country borders and requires coordinated cross-sectoral actions to prevent solutions transferring problems from one economic sector or environmental compartment to another.

The workshop was structured into three main sessions featuring a series of presentations given by scientists, policy makers and country representatives. The first session aimed at characterizing the current policies and international activities on nutrient management. In the second session the current profiles of nutrient loads to water bodies and national policies in Enlargement and Integration countries and selected EU Member States were presented. The third session concentrated on how to strengthen the knowledge base of integrated nutrient management as a support to policy making. Breakout groups were also organised to allow participants to discuss countries' experiences and perspectives and identify recommendations

[1]Enlargement and Integration countries are the new Member States (Bulgaria and Romania), Acceding Country (Croatia), Candidate Countries (Iceland, the former Yugoslav Republic of Macedonia, Montenegro, Serbia and Turkey), Potential Candidate Countries (Albania, Bosnia and Herzegovina, Kosovo under UN Security Council Resolution 1244), FP7 Associated Countries, European Neighbourhood Policy countries and Russia (Enlargement and Integration Countries).

[2] The Workshop Programme is provided in the Appendix A and the list of participants in the Appendix B.

for follow up actions, aim at improving integration of activities in Enlargement and Integration countries and EU Member States.

This report presents the contributions from the participants (Section 2), then the discussion in the breakout sessions (Section 3), and finally the recommendations that emerged from the Workshop (Section 4).

2. Extended Abstracts of Presentations

Nutrient pressures on water resources: EU Policy Framework

Francesco Presicce

European Commission, DG Environment

Francesco Presicce (European Commission, DG Environment, Unit for Agriculture, Forests and Soil) gave a presentation on the EU policy framework relevant to nutrient pressures on water resources. He explained that nutrients, which are a natural resource essential to life, could be harmful in case of losses to the environment and this issue has been tackled by environmental legislation since the early nineties.

The 7th Environment Action Programme[3] confirmed that although nitrogen and phosphorus inputs to the Union environment have decreased considerably over the past 20 years, excessive nutrient releases continue to affect air and water quality and to have a negative impact on ecosystems, causing significant problems for human health. Further efforts are needed to manage the nutrient cycle in a more cost-effective, sustainable and resource efficient way and a more holistic approach is needed to address the nutrient cycle.

The Nitrates Directive (91/676/EEC) addresses pollution caused by nitrates from agricultural sources, with the objective to reduce and prevent further such pollution. It requires Member States to monitor the quality of waters, identify polluted waters (or waters at risk of pollution), identify "Nitrate Vulnerable Zones" and establish Codes of Good Agricultural Practice and Action Programmes with a number of key measures relating to the application and management of fertilizers, including livestock manure. The Nitrates Directive has been yielding results (average nitrate levels have been decreasing in Europe), however more needs to be done, especially in areas with the highest agricultural pressures.

The Urban Waste Water Treatment Directive (91/271/EEC) relates to waste water discharges and establishes a number of obligations in terms of proper collection systems, appropriate treatment of collected waste water and reinforced treatment in areas sensitive to eutrophication. Investment resources to build infrastructure is generally the main bottleneck in implementing the directive. Long term investment planning (including EU funds) is needed.

The Water Framework Directive (2000/60/EC) is based on a new approach to water policy. As a "Framework Directive", it is designed to bring together all EU water policies, with the aim to achieve good status of EU waters by 2015 by means of integrated river basin management. In terms of implementation, Good Ecological Status by 2015 will not be reached for approximately 50% of EU waters and hydromorphologial pressures and diffuse nutrient pollution appear to be the most significant pressures EU wide. In particular, agriculture is identified as a significant pressure in more than 90% of the "River Basin Management Plans".

Finally, the Marine Strategy Framework Directive (2008/56/EC) sets the objective of achieving Good Environmental Status for marine waters by 2020 by means of coherent approaches across sea basins. Good Environmental Status is to be determined based on qualitative descriptors, which include a descriptor relating to human-induced eutrophication.

[3] DECISION No 1386/2013/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 November 2013 on a General Union Environment Action Programme to 2020 ‘Living well, within the limits of our planet’

Nutrient management relates also to the issue of resource efficiency. Phosphorus, which is a vital resource for agriculture and life, is characterized by a significant geographical imbalance of its resources and use, as well as environmental impacts across its life cycle. The 2011 "Roadmap for a resource efficient Europe" – COM(2011)0571 – called for further research in order to identify ways to reduce our dependence on mined phosphate. A "Consultative communication on the sustainable use of phosphorus" – COM (2013) 517 – was carried out in 2013. The stakeholders recognized the importance of the topic and responded to a number of specific questions. The results of the consultation will help shape further work of the Commission on this topic.

Francesco Presicce concluded recalling that nutrient management is a key environmental priority. Successful policy approaches have been developed, yielding results (e.g. reduction of nutrient inputs and decrease of average nitrate levels) and co-benefits in relation to other policies (ammonia emissions, greenhouse gases reduction, resource efficiency, etc.). However, the challenge of achieving nutrient conditions consistent with good status remains. This needs enhanced implementation of existing policies, which need to be considered within an integrated and holistic approach to addressing the nutrient cycle.

Global Nutrient Cycle Project

Albert Bleeker

Energy Research Centre of the Netherlands
on behalf of the Global Partnership on Nutrient Management

Introduction

The full title of this project is "Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle". According to the project description, the project is designed "to provide the foundations (including partnerships, information, tools and policy mechanisms) for governments and other stakeholders to initiate comprehensive, effective and sustained programmes addressing nutrient over-enrichment and oxygen depletion from land based pollution of coastal waters in Large Marine Ecosystems".

The project aims to develop and apply quantitative modeling approaches: to estimate and map present day contributions of different watershed based nutrient sources to coastal nutrient loading and their effects; to indicate when nutrient over-enrichment problem areas are likely to occur; and to estimate the magnitude of expected effects of further nutrient loading on coastal systems under a range of scenarios.

Here some project background is given together with its basic setup. Furthermore its current status and some of the outcomes are given.

Background

Growing concerns about the capacity of the earth's ecosystems (notably the marine environment) to absorb excessive (and growing) levels of nitrogen and phosphorus, were the direct reason for starting this Global Nutrient Cycle project. Nutrient over-enrichment and oxygen depletion of coastal waters in Large Marine Ecosystems (LMEs) is a direct consequence of these elevated nutrient levels and is an increasing problem worldwide. Reactive nitrogen production has increased more than 20 times from 1860 to 2005 and currently amounts to some 187 tonnes annually, around 1.5-2 times the natural rate for the planet as a whole. Estimates suggest that some 90 tonnes of this reactive nitrogen derived from land based human activities ends up in the world's oceans. Of the around 20 Mtonnes of phosphorus mined each year, nearly half is estimated to enter the world's oceans – 8 times the natural rate of input.

In coastal waters, this over-enrichment of nutrients cause phytoplankton and macro algae blooms. Overall this eutrophication can lead to the occurrence of harmful algal blooms, and oxygen depletion (hypoxia). Globally, harmful algae blooms are considerably more widespread and frequent than they were a decade ago, a situation that is expected to further deteriorate by 2020. Since 1960, the number of documented hypoxic areas has doubled every decade: in 2007, 415 eutrophic and hypoxic coastal systems were identified. Such areas are now present not only in enclosed seas, such as the Baltic Sea and the Black Sea, but also in large coastal areas which have internationally important fisheries. They are now spreading to developing countries, including large estuary areas such as the Changjing, Mekong Delta, and in the Arabian Sea. The current extent of hypoxic zones in the world's seas has been estimated as equivalent to the total global area of coral reefs.

It was this growing scientific but also political concern that was behind the request from the UN Global Environment Facility (GEF) for a project proposal addressing the different aspects of nutrient over-enrichment and oxygen depletion from land based pollution of coastal waters. In the following sections the basic setup of the project is shown, as well as some first outcomes.

Setup

The project was developed under the auspices of the Global Partnership on Nutrient Management (GPNM). GPNM provides a platform for governments, UN agencies, scientists and the private sector to forge a common agenda, mainstreaming best practices and integrated assessments in the context of nutrients.

To meet the objective that was mentioned in the Introduction, the overall outcome of the project aims for the provision of an applied, knowledge and stakeholder based managerial and technical framework, which:

a) Enables and stimulates countries and their stakeholders to instigate and implement cost effective programmes and policies to improve substantially nutrient management to the benefit of countries' coastal water quality

b) Provides a replicable model, both in terms of tangible tools (programmes, policies and regional models) and process (stakeholder engagement, partnerships), whilst recognizing that watersheds and coastal systems vary around the world

c) Works through a global partnership (and associated regional ones) to provide political stakeholder and scientific impetus at global, regional and national levels

d) Draws on previous GEF interventions and seeks to link them systematically in an overall policy tool box approach, promoting also broader GEF International Waters portfolio efforts on development of knowledge based, integrated interventions by countries and partners

e) Contributes to the mainstreaming of integrated coastal zone management and environmental sustainability and related international and regional programmes.

The key project outcomes are reflected in 4 main operational components under which the project is implemented:

A) The global partnership

B) The development of modeling techniques

C) The development of a Policy Toolbox and the integrations of the tools with the modeling techniques

D) Application of tools and modeling techniques in the Manila Bay watershed.

Next to these operational components, there are two over-arching components:

E) Monitoring and evaluation

F) Effective project co-ordination, management and over-sight.

Outcomes

The project will run for 3 years and started in April 2012. With only one year to go, the project now enters the phase where outcomes have become available. Although the most important results still have to be finalized in the coming period, some preliminary results are ready and will be presented during the workshop. Examples of these results are:

- Nutrient health reporting card for Lake Chilika (Orissa, India), one of the demonstration regions
- Overview of nutrient flows into the Manila Bay watershed, the other demonstration region
- Nutrient management database, to be used in the Policy Toolbox
- Basic setup for the Policy Toolbox, including an integration of Component B and C results

The International Nitrogen Initiative - A framework of international activities to tackle environmental impacts of nitrogen

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Introduction and Background

The International Nitrogen Initiative (INI) has been founded to explore and to tackle the "nitrogen paradox": nitrogen is a key element to allow plant growth, essential for food production. Yet the use of fertilizer to support crop growth – as well as the impacts of other compounds of chemically fixed nitrogen ("reactive nitrogen", Nr) – may lead to different types of environmental damage. Moreover, as Nr is "cascading" between environmental pools, it may contribute to environmental impacts at several stages. The "European Nitrogen Assessment" (see achievements, below) specifically names air pollution, water pollution, soil pollution, greenhouse gas emissions, and biodiversity as issues to be considered as Nr-induced threats.

INI was established in 2003 as a joint SCOPE/IGBP project (without funding) serving as a communication platform of scientists focusing on nitrogen related environmental issues. It operates globally, with the activities organized in six regional centers. The European center of INI (INI-Europe) is now hosted by the Austrian Academy of Sciences, Climate and Clean Air Commission. Previously, it was operated at ECN in Petten, The Netherlands, and at CEH Edinburgh, UK. The steering board currently consists of Hans van Grinsven, Bruna Grizzetti, Kevin Hicks, Maren Voss, Wim de Vries, and Wilfried Winiwarter.

INI Objective and key focal areas

INI-Europe facilitates enhanced cooperation and integration among European researchers, policy makers and practitioners to cover environmental issues related to Nr. INI-Europe's task includes to inventory, review and synthesize work from existing related activities, like those of EUROSTAT and OECD, the TFRN (Task Force on Reactive Nitrogen) and its expert panels, and the ongoing work in research projects under EU's 7th Framework programme or similar activities.

Addressing several key focal areas, the aim, the topics to investigate, the rationale behind and the approach that may be taken will be summarized.

1. Regional N budgets and N pathways/emissions

Aim: Create regional nitrogen budgets and assess/quantify the respective flows (distinguishing farm, soil, land and total N budgets)

Rationale: Extending from the European Nitrogen Assessment (ENA), budgets on different scales intend to identify intervention points to regulate and abate N flows.

Approach: liaise with EPNB, the Expert Panel on Nitrogen Budgets operating under the Convention on Long-Range Transboundary Air Pollution, and with related activities of Eurostat and OECD. INI-Europe will support individual country activities, e.g. those currently developed by Denmark.

2. N compounds in air and water and their relation to effects on ecosystems and human health

Aim: Quantify and prioritize risks and risk treatment associated with Nr, now and in a future situation

Rationale: These areas are the key policy drivers in Europe

Approach: ENA managed to tackle this issue doing cost-benefit analyses. This approach has been updated and again published. Still considerable further activity is needed to appropriately value the risks in ecosystems as well as human health. Using a numeraire of monetary terms may be considered less than ideal, possibly applying relative risks may be a way to proceed.

3. Effects of N inputs on terrestrial ecosystems, in interaction with air quality and climate change

Aim: Assess effects of N inputs, in interaction with air quality and climate change, on terrestrial ecosystems in terms of productivity and carbon sequestration, and of biodiversity (plant species diversity)

Rationale: The impact of N inputs on C sequestration is highly relevant but should be evaluated in view of other drivers (CO_2, O_3, climate and other nutrients including P). Furthermore, the interaction of climate change with N inputs on biodiversity should gain more attention.

Approach: This can be related to work in the ÉCLAIRE project.

4. N inputs and effects on aquatic/marine ecosystems

Aim: Assess effects of N inputs, in interaction with P and Si inputs, on aquatic and marine ecosystems in terms of productivity and carbon sequestration, and of eutrophication

Rationale: The ENA focus was on N as such, but interaction with other drivers, i.e. phosphorus, P, and silica, Si, (as the *Indicator* for Coastal Eutrophication Potential) should get more attention in view of the eutrophication of European surface waters. The ENA refers in its water quality chapter to global NEWS that makes such predictions. However, global NEWS is a low spatial resolution global scale model in which furthermore P from land is built in by a steady state approach. Updating NEWS by including dynamic P processes using higher resolution input data for Europe and comparing with other models, such as GREEN is relevant here.

Approach: Try to link this work to upcoming Horizon 2020 call. An aspect that could be considered relevant is the evaluation of impacts of bioenergy crops on eutrophication in view of elevated N and P use (this also holds for the other topics like NH_3 emissions etc., but the relation to eutrophication seems most prevalent).

5. Link N and P use with food productivity and assess regional (country and continental) transfer of N and P to both food productivity and adverse environmental impacts

Aim: Assess the N (and P use) efficiencies in food chains in European countries as a basis for improving the NUE and PUE

Rationale: understanding nutrient flows in its chain is another way to identify intervention points, and to establish resource efficiency.

Approach: N footprint calculator (Jim Galloway/Albert Bleeker) and supply chain analysis at SEI

6. Assess regional boundaries for N and P use in view of food production and adverse environmental impacts

Aim: Assess boundaries for N and P use at country level and even lower levels (e.g. NUTS2 level) for possible governance use accounting for the trade-off between the need of nutrient use for food security versus the harmful effects of over application.

Rationale: Human interference with the N cycle is identified as a system that may already have exceeded its planetary boundary, was based on the production of new reactive N. However, this value was simply set at 25% of its current value and requires update. Furthermore, unlike climate change and biodiversity loss which are also assumed to be exceeded, a global threshold for N is absent with the exception of N_2O, thus challenging a planetary boundary and requiring regional boundaries.

Approach: Support of work related to (i) identification of multiple threat N indicators and setting critical limits for them, (ii) back calculating critical N losses from critical limits for N indicators, while accounting for the spatial variability of indicators and their exceedance and (iii) back calculating critical N fixation rates from critical N losses, with an aim to closing nutrient cycles.

7. Improving N management across Europe and current best practice in Europe

Aim: Devise practicable implementations of NUE efficiency improvement for the diversity of European situations

Rationale: Close science-policy gap by coming up with practically useful proposals

Approach: Devise recommendations based on individual studies and activities for the diversity of European situations (from excess nutrients to deficiencies, from water scarcity to abundance, from moderate temperature ranges to high/low extremes).

Achievements

INI has been successful in the past to host and to contribute to workshops and conferences, operate as the focus of research projects and activities, and to edit major assessment studies. A tri-annual conference series has been alternately organized by each of INI's regional center, with the latest, the 6th International Nitrogen Conference, held in Kampala, Uganda, November 2013. INI-Europe co-sponsored the 18th Nitrogen workshop in Lisbon, July 2014.

Among other activities, INI was central in establishing COST action 729 "Assessing and managing nitrogen fluxes in the atmosphere-biosphere system in Europe". Also, the ESF network NinE (Nitrogen in Europe) was closely linked to INI-Europe, as also the EU funded project Nitro-Europe and ÉCLAIRE.

The most prominent output of INI-Europe has been produced in form o its scientific assessment reports, taking advantage of the network of experts assembled under the initiative. Each of these assessments can be accessed and downloaded in full text. The European Nitrogen Assessment (ENA), published by Cambridge University Press (Sutton et al., Eds., 2011) has become the standard text of nitrogen related environmental issues in Europe – covering sources, physical transformations, impacts, and the role of society in general with regard to Nr. Together with the Global Partnership in Nutrient Management, INI published "Our Nutrient World", a report promoting sustainable production and use of nutrients globally, putting food production in the center of attention while suggesting options to minimize nitrogen related impacts. Moreover, INI significantly contributed to UNEP's synthesis report "Drawing Down N_2O To Protect Climate and the Ozone Layer", describing potentials to reduce the release of the stable atmospheric component nitrous oxide. All these assessments have been backed by relevant scientific publications in well-regarded scientific journals (see INI web site).

Policy Impacts

While INI covers nitrogen and Nr generally, policy applications typically still address individual problem areas, even if policy makers recognize the risks of interferences and the importance of integrated views. Water-related issues of nutrients generally, and specifically nitrogen can be found elsewhere in this report. Moreover, INI reaches out to air quality policy and offers collaboration. The Task Force on Reactive Nitrogen (TFRN) operates under the Convention on Long Range Transboundary Air Pollution, and provides technical support of the possibilities and extent of emission reduction measures, specifically on ammonia. Nevertheless, the Task Force also reaches out to cover impacts between media, with an Expert Panel on Nitrogen Budges, an Expert Panel on Nitrogen and Food, and an expert group on N and climate. These mechanisms allow to bring scientific evidence developed by INI (specifically by INI Europe) directly into policy applications.

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Integrating science and policy for using wetlands for controlling eutrophication of downstream aquatic ecosystems: Three case studies in the USA

William J. Mitsch, Ph.D.

Eminent Scholar and Director, Everglades Wetland Research Park Juliet C. Sproul Chair for Southwest Florida Habitat Restoration and Management Editor-in-Chief, Ecological Engineering Florida Gulf Coast University, 110 Kapnick Center, 4940 Bayshore Drive, Naples FL 34112 USA

Nitrogen and phosphorus are in great abundance relative to needs by the landscape in many parts of the world, leading to excessive nutrients being exported to downstream aquatic ecosystems. This presentation reviews the role that creating and restoring wetlands has on minimizing nutrient fluxes in three distinct cases of wetlands being proposed or used for nutrient retention in the USA. These projects are all at different levels of design, implementation, and public acceptance but with common threads of difficulty in both the science and policy arenas.

In the south Florida Everglades, an ambitious plan of agricultural stormwater treatment by wetlands is occurring in the Florida Everglades where 23,000 ha of created wetlands, called Stormwater Treatment Areas (STAs), have been created for phosphorus control from upstream agricultural areas (Fig. 1a).

The main cause of the spread of cattail (Typha domingensis) in the otherwise nutrient-poor Florida Everglades dominated by sawgrass (Cladium jamaicense) is nutrient enrichment—especially by phosphorus emanating from agricultural areas in the basin.

There are currently six stormwater treatment areas (STAs) treating agricultural runoff from the EAA south of Lake Okeechobee. Some of these systems have been in operation for almost 20 years (Fig. 1 b). Overall, from their start through 2012, these wetlands reduced phosphorus loads by 73 % and lowered the average phosphorus concentrations from 140 to 37 ppb (Fig. 1c). The wetlands were originally designed to reduce phosphorus to 50 µg-P/L, a 60 to 75 percent reduction in phosphorus. That effluent goal has been reduced by authorities to 10 µg-P/L, essentially background concentrations of phosphorus in the oligotrophic Everglades. Reaching this mandated 10 ppb threshold of total phosphorus has not been achieved with any consistency from the STAs. A multi-year mesocosm study that investigated different plant communities showed that 10 ppb of phosphorus may possible when the inflow is the effluent coming from the STAs (Mitsch et al., in review).

Humans have essentially doubled the amount of nitrogen entering the landbased nitrogen cycle through fertilizer manufacturing, increased use of nitrogenfixing crops, and fossil fuel burning. Significant amounts of this excess nitrogen are transported as nitrate-nitrogen to rivers and streams, leading to eutrophication and episodic and persistent hypoxia (dissolved oxygen <2 mg/L) in coastal waters worldwide. For example, a hypoxic zone that currently averages close to 12,500 km2 reappears annually in the Gulf of Mexico, caused almost certainly by excessive nitrogen coming from farm fields in from the Mississippi-Ohio-Missouri (MOM) river basin 1000 km to the north of the Gulf (Fig. 2). The extent of the hypoxia was much smaller than that area in

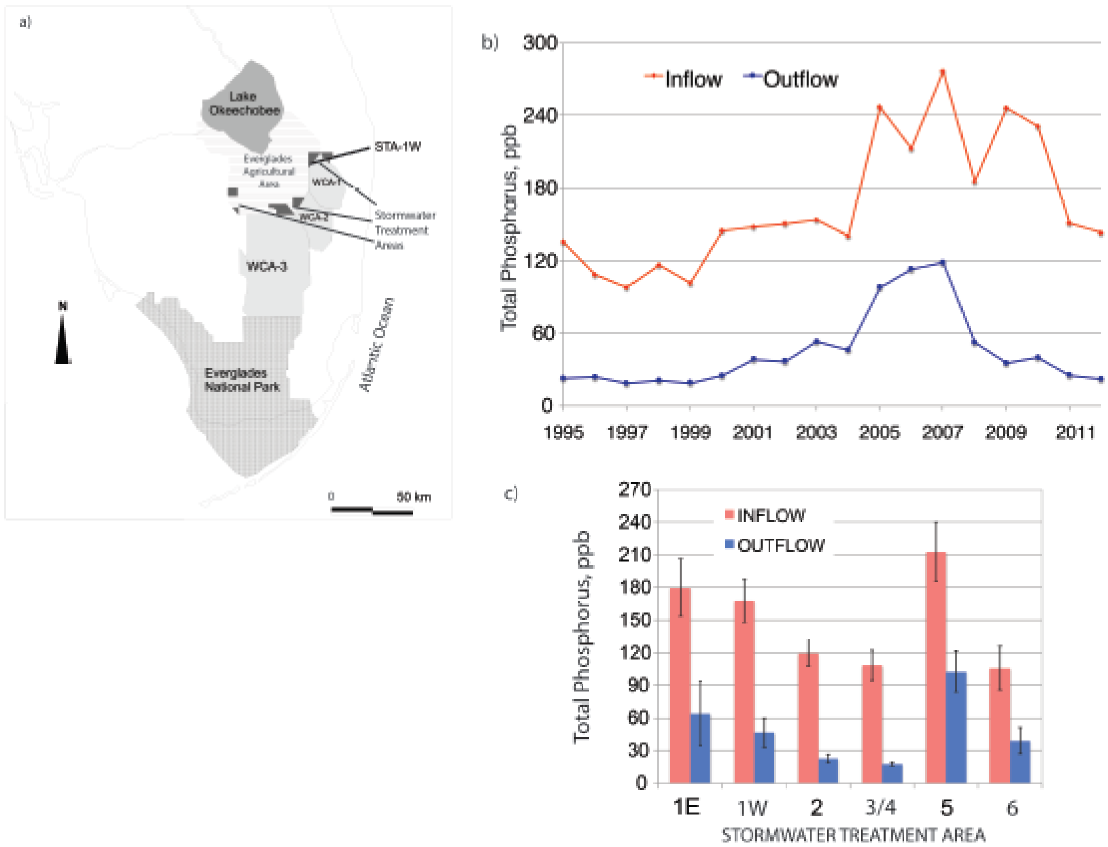

Figure 1. Stormwater Treatment Areas (STAs) downstream of the Everglades Agricultural Area that were created/restored to protect the downstream oligotrophic Florida Everglades a) location of the STAs in south Florida; b) inflow and outflow concentrations of total phosphorus in STA 1W, 1995-2012; c) comparison of phosphorus concentrations in inflows and outflows of six STA complexes. (From Mitsch and Gosselink, 2015; data courtesy of South Florida Water Management District, West Palm Beach, FL)

the late 1980s and the Federal government decreed in 2000 and then again in 2008 that the hypoxia should be no larger than 5000 km2.

Many options were investigated for controlling nutrient flow into the Gulf by research teams in the late 1990s (e.g., Mitsch et al., 2001). In the end, there were the general approaches that involve either revision of agronomic approaches or wetland creation and riparian restoration that make the most sense. In the Midwestern United States, created riparian wetlands have shown patterns of nutrient and sediment retention over many years of study. For 17 years (1994–2010) the kidneyshaped experimental wetlands in Ohio consistently reduced total phosphorus, soluble reactive phosphorus and nitrate + nitrite-nitrogen concentrations were by about 20 to 60 percent. Both total phosphorus and soluble reactive phosphorus showed trends of decreased retention over that 17-year period (Mitsch et al., 2012), with the wetlands actually exporting total phosphorus in one year. Nitrate-nitrogen retention showed a steady pattern over the last six years of the study. There has been little difference in nutrient retention between the two experimental wetlands since they were created in 1994, even though one of the wetland basins was planted in 1994 and the other was allowed to colonize naturally. Estimated from this and other wetlands in the Mississippi River Basin led to conclusions that about 2 million ha of these types of wetlands are needed to significantly reduce the nitrogen coming from the USA Midwest (Mitsch et al., 2001, 2005).

A third case where a return of massive eutrophication that has returned to the Laurentian Great Lakes has led some to suggest a major program of riparian corridor restoration and wetland creation and restoration. “Nutrient impairment continues to plague Lake Erie, impacting an $11.5 billion tourism industry” according to Ohio Lake Erie Phosphorus Task Force in Nov 2013. The problem pollutant is phosphorus “again” as many remember the “Lake Erie is dying” chant in the 1960s and 1970s that was thought to have been solved in the 1990s with major expenses of in tertiary wastewater treatment plants in the basin. Now it is clear that non-point source pollution from agricultural fields is the main source of the problems in western Lake Erie. Nonpoint source pollution now accounts for almost 70% of the inflow of phosphorus to Lake Erie and the shallow western basin of the lake receiving 60% of the total phosphorus load. At one time a large wetland known as the Black Swamp, a combination of marshland and forested swamps that serves as the western extension of Lake Erie and covered an estimated 400,000 hectares (Mitsch and Gosselink, 2015).

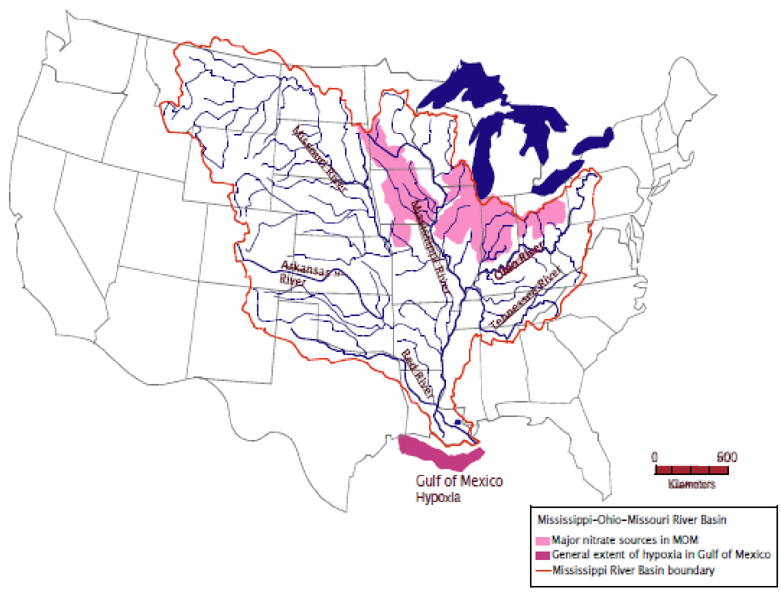

Figure 2. The 3 million km2 Mississippi-Ohio-Missouri (MOM) river basin showing the location of highest nitrate-nitrogen concentrations in the upper basin and the Gulf of Mexico hypoxia 1000 km to the south (from Mitsch et al., 2005).

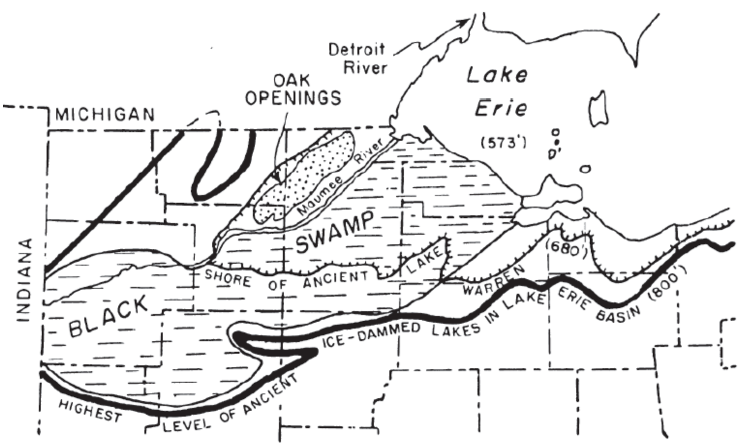

Figure 3. Historic Black Swamp that has been completely drained, mostly for agricultural development, in northwest Ohio. The Maumee River that is the main source of phosphorus to western Lake Erie is shown on the northern border of the former Black Swamp (from Mitsch and Gosselink, 2015).

The swamp was bordered on the north by the Maumee River, which brings most of the phosphorus to Lake Erie. Restoring significant portions of the Black Swamp with diversions of river water and local diversions from local agricultural fields needs to be seriously investigated. Of course there are many issues related to financing this approach as well as making it fair to land owners, but a system not unlike the STAs in the Florida Everglades should be investigated.

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Management of nutrient losses in Denmark

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Five major Action Plans on the Aquatic Environment have been implemented in Denmark since 1987 with the aim to reduce by 50% the nitrogen (N) loading and by 80% the phosphorus (P) loading to the aquatic environment. At the same time the Danish National Aquatic Monitoring and Assessment Programme (NOVANA) was launched with the aim to follow the effects of the obligatory implemented management strategies in Danish agriculture. Monitoring of the effects took place in 5 small agricultural catchments in soil water, groundwater and surface waters with annual interviews of farmers practices at field level as well as a general monitoring of nutrient concentrations in groundwater, streams, rivers, lakes and estuaries all over Denmark (Kronvang et al., 1993; Kronvang et al., 2005).

The nutrient emissions to marine waters are measured every year at ca. 120 coastal near monitoring stations covering ca. 50% of the Danish land area. Nutrient emissions from the remaining ungauged part of the country is estimated utilizing a national model (DK-QNP) which links a 3D hydrological model (MIKE SHE) with data on discharges from point sources, empirical models for diffuse nutrient losses and models for nutrient retention in surface waters (Windolf et al., 2011).

Major changes have occurred in the emission of nitrogen and phosphorus to marine waters in Denmark during the period 1990-2012 (Fig. 1 and 2). The emissions from point sources of total N and total P has been reduced due to improved sewage treatment in all types of point sources (urban waste water treatment plants, industrial plants, fish farms, scattered dwellings and urban storm water runoff). Nitrogen removal and phosphorus precipitation has been established at virtually all wastewater

treatment plants with a capacity exceeding 5,000 PE in order to meet the discharge standard of 8 mg N/L and 1.5 mg P/L specified in the 1987 Action Plan on the Aquatic Environment I. Emissions of total N from point sources in Denmark to the aquatic environment has been reduced from 24,000 tonnes N to 5,700 tonnes N (76%) during the period 1990-2011 (Fig. 1). A strong reduction has also been accomplished in the emission of total P from point sources to the aquatic environment which has been reduced from 4,870 tonnes P to 790 tonnes P (84%) during the period 1990-2012 (Fig. 2).

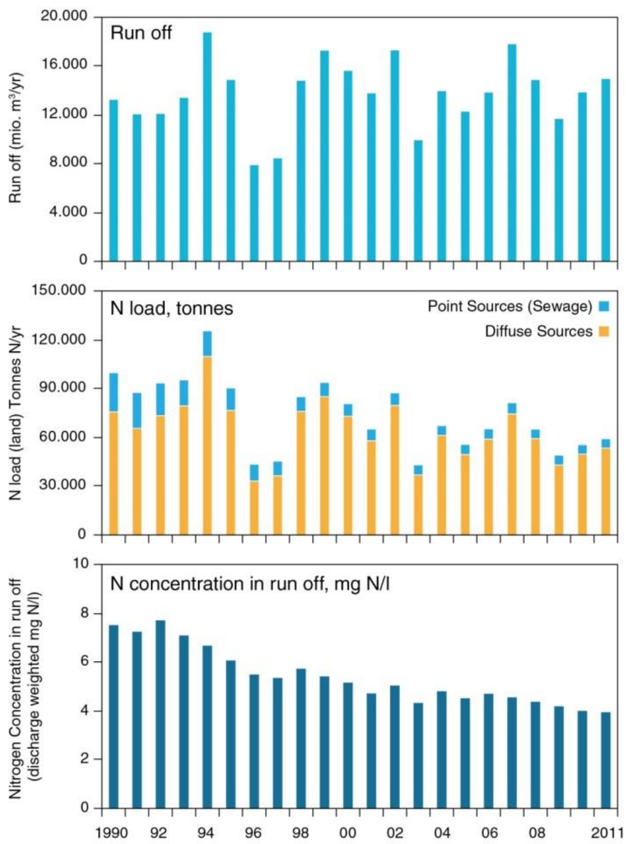

Figure 1: Water runoff, total nitrogen loadings and flow weighted concentration of total N in the loading to coastal waters around Denmark during the period 1990-2011.

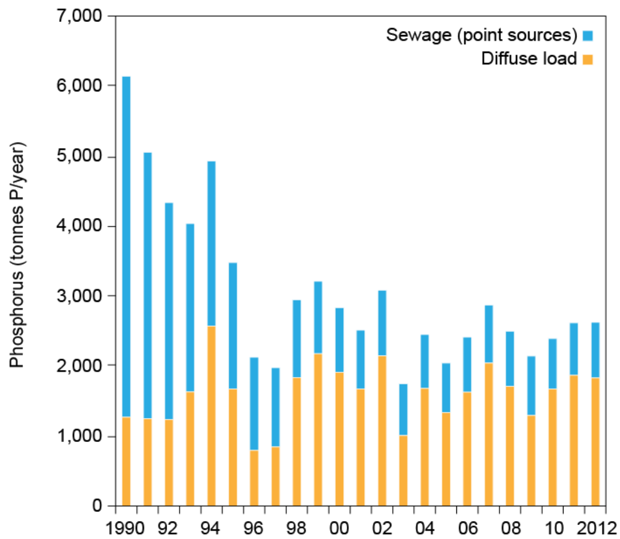

Figure 2: Loadings of total P to coastal waters around Denmark during the period 1990-2012.

Twenty-five years of experience gathered from NOVANA have shown that the losses of total N and total P to the marine environment has been reduced from ca. 100,000 tonnes N around 1990 to 50,000-55,000 tonnes during the recent years (Fig. 1). The reduction in diffuse total N losses amounts to 40% during the period 1990-2011 (fig. 1). The total phosphorus loadings have also been reduced from ca. 6,000 tonnes P to 2,600 tonnes P during the period 1990-2012 but the reductions are solely due to improved sewage treatment and lower point source emissions as no general reduction in TP from diffuse losses can be detected (Fig. 2).

The reason behind the large reduction in nitrogen losses from diffuse sources is a considerable changes in agricultural practice (storage of slurry, ban on slurry spreading in autumn and winter, strict requirements to N-use in animal manure, N-norms to all crops to be fixed to 10% below economic optimum, etc.) have resulted in a reduction of the net N-surplus on agricultural land in Denmark from 136 to 75 kg N ha^{-1} yr^{-1} (45%) and the net P-surplus from 19 to around 0 kg P ha^{-1} yr^{-1} (100%) during the period 1985–2011.

Despite the great efforts in improving the management of N and P in Danish agriculture the sector is still today the major source of both N (80%) and P (50%) in Danish streams, lakes and coastal waters. The ecological conditions in Danish streams, lakes and estuaries are still below the at least good ecological quality required by the EU Water Framework Directive adopted in year 2000. As global demand for food is increasing the Danish Government last year initiated a commission to publish a white book on 'Nature and Agriculture'. The commission has just published their recommendations for the future regulation and management of the Danish agricultural production as the aquatic environment still needs to be improved, and concurrently, the airborne nutrient load on nature must be reduced, and agriculture must help reduce the overall climate-change impact. The Commission suggests that the current environmental regulation of agriculture with general fertilizer norms and limits on production cannot alone deal with the challenges, because the costs will be too high for the farmers. They, conclude that it is necessary to explore new territory and make regulation more targeted. Recommendations by The Commission are for more targeted and efficient environmental regulations in agriculture. New differentiated and targeted regulations mean that agricultural operations in the resilient areas can be adjusted and optimized, and the most vulnerable agricultural areas can be subject to extensification or conversion to non-agricultural natural land. The aim of this contribution is to highlight the results obtained within agriculture and the aquatic environment in Denmark from 25 years of general regulations of agricultural production and set the scene for the future more targeted and local regulations.

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Mitigation options to reduce nutrient losses from land to surface water

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Introduction

The role of nutrients phosphorus (P) and nitrogen (N) in the eutrophication of surface water was already recognized in the mid of the twenties century (Redfield, 1958). Negative effects of eutrophication caused a reduced functioning and biodiversity of aquatic ecosystems and surface water quality. Toxic substances produced by blue-green algae may cause fish kills, and animal and human diseases (Burkholder, 1998; Smith et al., 1999). Avoiding these potential harmful effects, and reducing nutrient losses to the aquatic environment has received much attention. Due to improved wastewater treatment, phosphorus losses from point sources has decreased, and focus is now on reducing loss from diffuse sources (Sharpley and Withers, 1994; Sharpley et al., 2001; Sharpley et al., 1994; Withers and Jarvis, 1998). Within the European Union, this process is accelerated by the Water Framework Directive (WFD; Directive 2000/60/EC) that requires improvement of the quality of surface and groundwaters (Kronvang et al., 2005).

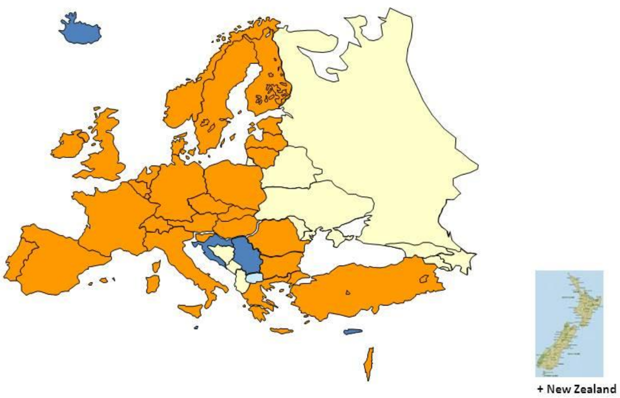

Figure 1. Countries participating in COST Action 869 (in brown).

During the period 2006-2011 COST Action 869 "Mitigation options for nutrient reduction in surface water and groundwaters" (see www.cost869.alterra.nl) was carried out. At the end of COST 869 a total of 30 countries participated in the Action (Figure 1). One of the main objectives of COST 869 was to undertake a scientific evaluation of the suitability and cost-effectiveness of different options for reducing nutrient loss to surface and ground waters, at the river basin scale. This includes their limitations in terms of applicability under different climatic, ecological and geographical conditions. COST 869 focused on the steps that need to be taken within the EU Water Framework Directive in order to effectively reduce the nutrient losses from point and diffuse sources to surface waters and groundwater. The main focus was on reducing P losses as one of the main sources of eutrophication of fresh water systems. Furthermore, the impact of pollution swapping of measures was taken into account (e.g. increase nitrogen losses). During the COST action a series of factsheets were written and made available online.

Development of factsheets

Based on information from literature and an inventory amongst participating countries, 83 measures were distinguished and grouped into eight categories: (1) nutrient management, (2) crop management; (3) livestock management; (4) soil management; (5) water management within agricultural land; (6) land use change; (7) landscape management and (8) surface water management. Each measure was described in a factsheet with the following sections:

- *Description*, including whether the mitigation effect targets P (or N).
- *Rationale, mechanism of action:* describes the mechanism to retain P (and N).
- *Relevance, applicability & potential for targeting*: describes under which conditions the option can be applied.
- *Effectiveness, including uncertainty*: estimates how effective the option can be, under which conditions it will be most effective and under which conditions it is least effective.
- *Time frame:* indicates if the option is assumed to be effective in the short, medium or long term.
- *Environmental side-effects / pollution swapping*: indicates unwanted effects in other environmental compartments.
- *Administrative handling, control:* describes the ease of applying and controlling the application of an option.
- *Costs:* since actual costs can vary greatly between, and even within countries, only investment and maintenance costs are defined.
- *References:* the references given are preferably easily accessible, e.g. via a link.

All 83 mitigation measures are described individually on the website http://www.cost869.alterra.nl/Fs/List_of_options.htm. In order to structure the different types of mitigation options for reducing nutrient losses, a framework was created of systems influencing the surface water quality. It comprises four systems (Schoumans et al., 2014; Schoumans et al., 2011) (Figure 2).

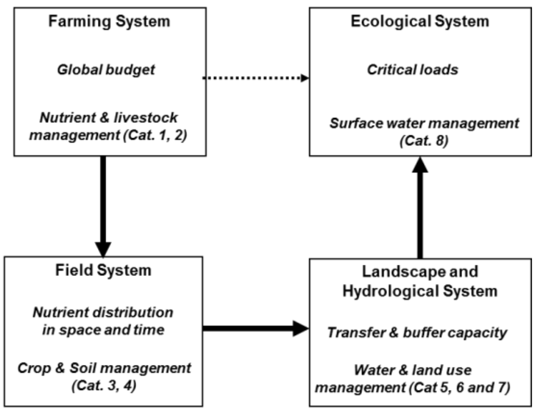

Figure 2. Schematic visualisation of the systems determining nutrient losses to surface water, with the defined categories of mitigation measures (source: Schoumans et al., 2013).

At the farm scale, strategic socio-economic decisions are made about the production system, and often nutrient management and livestock management strategies are developed in order to comply with European and national legislation. Farm-gate nutrient budgets based on the nutrient and livestock management give valuable information about the potential pressure of nutrients in the region (I. Farming system). The distribution of the available P sources over the fields in space and time depends on the crops and the soil P status, and gives more information about the soil balances and the potential risk of losses from the fields (II. Field system). Actual P losses from the fields to surface waters strongly depend on the landscape and its hydrology in a given region, because those systems determine the transfer and buffer capacity for nutrients (III. Landscape and hydrological system). The impact of nutrient loads on the ecology of surface waters (IV. Ecological system) depends on the actual nutrient pressure compared to the critical nutrient pressure. During the presentation for each of the systems the main findings will be presented.

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Temporal changes in nutrient concentrations and losses from agricultural streams in the Nordic and Baltic countries

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Assessment of long-term trends is one of the key objectives in most national water quality monitoring programmes. It is for example essential that we know how long it can take to detect the response in agricultural streams to changes in agriculture and implemented measures, because such information is needed to allow environmental authorities and decision and policy makers to establish realistic goals. Thus, long-term monitoring data is the key to cover future management needs and demands such as implementation of various EU-Directives (e.g., WFD, the Nitrates Directive).

This paper in a uniform fashion examines the temporal trends of nutrient concentrations and losses in streams draining agricultural catchment areas in the Nordic and Baltic countries. 35 catchments (range 0.1-33km^2) in Norway (9), Denmark (5), Sweden (8), Finland (4), Estonia (3), Latvia (3) and Lithuania (3) were selected for the study. The longest time series where 23 years (1988-2010) while the shortest one was 10 years (2002-2011).

Both total nitrogen, total phosphorus and dissolved reactive phosphorus was analysed statistically.

Trends in land use, agricultural management and implementation of mitigation measures will be assessed to explain the trends in water quality.

Furthermore, the difference in mean level concentrations and losses will be discussed in relation to differences in climate, land use, agricultural management and implementation of mitigation measures.

The oral presentation stems from the following papers:

Per Stålnacke, Paul Andreas Aakerøy, Gitte Blicher-Mathiesen, Arvo Iital, Viesturs Jansons, Jari Koskiaho, Katarina Kyllmar, Ainis Lagzdins, Annelene Pengerud, Arvydas Povilaitis. 2014. Temporal trends in nitrogen concentrations and losses from agricultural catchments in the Nordic and Baltic countries. Agriculture, Ecosystems and Environment (in press)

Annelene Pengerud, Per Stålnacke, Marianne Bechmann, Gitte Blicher-Mathiesen, Arvo Iital, Jari Koskiaho, Katarina Kyllmar, Ainis Lagzdins, Arvydas Povilaitis. 2014. Temporal trends in phosphorus concentrations and losses from agricultural catchments in the Nordic and Baltic countries (submitted)

Nitrogen and phosphorus in Europe's waters: Integrated assessment

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Protecting water resources is high on the European Commission's agenda and several pieces of legislation have been enacted to protect the quality and the quantity of the resource since the beginning of the '90s. The Water Framework Directive (WFD) is the key policy in the field of water protection and it requires Member States to achieve good ecological and chemical status of all water bodies by 2015. Other legislations are also in place to protect pollution from point and diffuse sources. Excess nitrogen in surface water was identified very early as a potential problem and led to the adoption in 1991 of the Nitrates Directive, which deals with the protection of waters against pollution caused by nitrates from agricultural sources, and of the Urban Waste Water Treatment Directive, to control nutrient pollution from point sources.

Despite the large and strict body of legislation to control water quality, many European river basins will not achieve the goal of good chemical and ecological status by 2015, as required by the WFD, and local and regional eutrophication is still occurring in Europe's waters. When fully implemented, the key directives have helped decrease the amount of nutrient input. However, the implementation is still lagging behind in some countries and water quality has not reached the expected levels of improvement considering that the Nitrates and Urban Directives have been in place for more than 20 years. In addition, inertia and the delay (several decades) in the response of the environment to the mitigation measures for reducing nitrogen losses is responsible in many areas for subdued or no improvement in water quality (Bouraoui and Grizzetti 2011).

The Joint Research Centre (JRC) has engaged in developing and implementing modelling tools to support policy makers and managers in analyzing the problems linked to excessive nutrients in the environment and proposing appropriate solutions. The modeling tools are currently being used to identify hot spots and trends of nutrient losses, determine major sources of pollution, and identify sound and economically sustainable management practices to improve or maintain water quality.

Among the modelling tools, the JRC has developed a statistical model for quantifying fluxes of nutrients to the sea and apportioning the losses according to industrial, agricultural and urban activities (Grizzetti et al. 2012; Bouraoui et al. 2011). It was estimated that the losses to all European Seas amounted to about 4.1–4.8 Tg yr^{-1} of nitrogen and 0.2–0.3 Tg yr^{-1} of phosphorus between 1985 and 2005. It was predicted that agriculture is responsible for about 60% and 30% of the nitrogen and phosphorus losses, respectively. Point sources accounted for 20% and more than 60% of the nitrogen and phosphorus losses, respectively. The statistical model was used to test several management alternatives (Thieu et al. 2012). It was predicted that optimized use of manure including appropriate application rate according to crop requirement, and complemented if required by mineral fertilizer, was the most efficient way in reducing nitrogen losses to surface and groundwater. For phosphorus, the highest reduction in loads was obtained through a full implementation of the Urban Directive and banning phosphorus based detergents.

The JRC has also set up EPIC and SWAT two physically based models that simulate the impact of agricultural activities on water quality at the European scale. The EPIC model was used to calculate the nitrate leaching below the root zone. It was also used to elaborate appropriate agricultural management practices to reduce nitrate leaching. In particular, the option of optimized fertilization (by applying fertilizer when needed by crops and in the appropriate amount) was tested. It was shown that using an optimal fertilization strategy can significantly reduce the nitrate leaching below the root zone. Few areas are still exhibiting large nitrate losses even under an optimization strategy due to the climatic and soil conditions, or also due to the application of large irrigation amounts that leads to elevated losses of nitrate, calling for an integrated water/nutrient management. In this context, the JRC has linked the three dimensional model SWAT with a multi-objective optimization tool to analyze tradeoffs between alternative management scenarios to provide managers with a panoply of potential solutions on which to engage debate with stakeholders in order to come up with the most consensual solutions.

The results of our studies show how integrated nutrient assessments can support the implementation of the EU water policy, highlighting spatial and temporal patterns of nutrient pollution, and how models can be useful tools to assess the effectiveness of policies, support the planning of remediation measures, and overcome the lack of information.

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BULGARIA

Nitrogen pollution in Bulgaria - Characterization and solutions

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National Institute of Meteorology and Hydrology at the Bulgarian Academy of Sciences

State of the surface, and air nitrogen pollution

The nitrogen pollution of the surface and groundwater and the atmosphere is an important problem for the public water supply and the struggle with the climate changes in Bulgaria. The basic sources for nitrogen emissions with human origin are the agriculture, industry and the urbanisation.

The agriculture is the greatest polluter of the waters introducing mineral and organic fertilizers into the soils. Its application is of essential importance for high yields but the excessive use leads to irreparable harms to the groundwater as well as to the surface waters, accumulated at the end in great basins. The nitrogen in the water is in nitrate form (NO_3), easily is moved with the surface water flow and through the soil profile as well. Another harmful consequence of the fertilizer use is the nitrogen emissions (N_2O) to the atmosphere. The latest scientific investigations on the climate change reveal that the nitrogen emissions are disastrous for the ozone layer too and that N_2O is the leader in its destruction. Its potential is many times greater than the one of the carbon dioxide (CO_2). It is proved that 2/3 of N_2O is emitted from the agricultural lands as consequence of improper fertilizer use [4]. The industry and the urbanization on the other hand are the main causer for the catastrophic increase of the NO_2, thus contributing indirectly to the climate changes and the acid rains.

Bulgaria as a member of the EU from 2008 applies the EU directives and actively fights the problem through monitoring of the surface and groundwater quality, of the soils and the air with respect to the nitrogen emissions, identification of the nitrate polluted waters and the vulnerable zones on the country territory [1,2,3]. It has as well prepared program of measures for prevention and limitation of the nitrate pollution from agriculture sources in the vulnerable zones. The water management at national level is effectuated by 4 Basin Directories. The monitoring of the surface waters is performed monthly and that of the groundwater – 4 times per year.

The water bodies monitoring in the periods 2004-2007 and 2008-2011 shows in general slight and stable improvement of the water quality and lowering of the nitrate concentration [1]. It doesn't anyway mean the problem has been overcome. The status of the water bodies in the vulnerable zones, mainly in the area of the Danube and East Aegean basins, is bad. The last reports data from 2013 show raise of the nitrate concentration in the surface waters compared to those in 2012 [2]. The same in the groundwater steadily remain above 50 mg/l. On places in the Danube Basin area measured are concentrations up to 140 mg/l, while in the East Aegean Basin in unconfined aquifers they reach as high as 230 mg/l. The worse is that in the lower layers of the groundwater the nitrate concentration reaches up to 120 mg/l. These aquifers are the only sources for drinking water in cases of hazardous situation, so that emergency measures should be taken for improvement of the situation.

There are not data about the air quality over Bulgaria concerning the N_2O but in the country report for the periods 2003-2007 and 2008-2011 [1] it has been accounted for 14% increase of the mineral fertilizers application. It inevitably should have led to a raise of the N_2O emissions.

The monitoring of the tropospheric NO_2 over Bulgaria by the satellite measurements of SCIAMACHY (Scanning Imaging Absorption Spectra-Meter for Atmospheric Cartography) during the period 2002-2011, shows slight and stable trend to a rise of the nitrogen emissions Fig.2 [6]. The average NO_2 value for the country is close to the maximum permissible level $3,93.10^{15}$ molecules cm^{-2}. It is reported mean values $2,9.10^{15}$ for Sofia, $2,6.10^{15}$ for Kozlodui and $2,7.10^{15}$ for Maritza [8]. But the NO_2 at hot spots in the country are measured up to $6,2.10^{15}$ [7], which is 1.5 above the norms. Certainly the country is not one of the great polluter of the air (Fig.1) but further increase of the pollution emissions is not admissible. A negative effect of the increase of the nitrogen emissions are the acid rains. The monitoring of the National Institute of Meteorology and Hydrology (NIMH) during the last year witnesses higher acidity of the rains juxtaposed to its average value in the period 2002-2010.

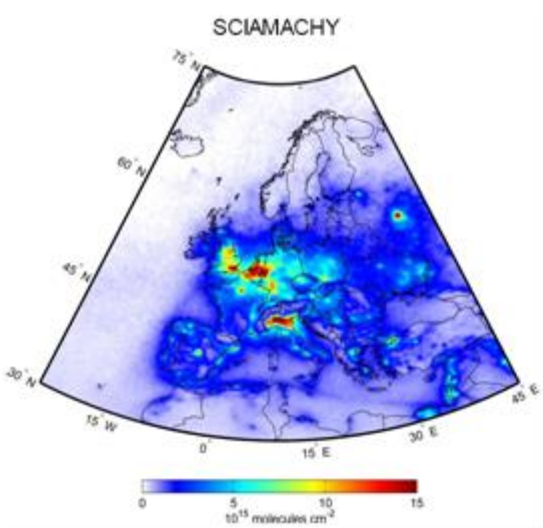

Fig.1 Mean tropospheric NO_2, 2002 – 2011

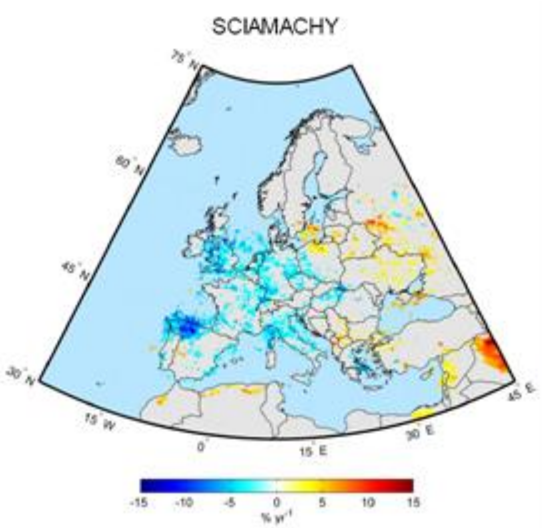

Fig.2 Trend tropospheric NO_2, 2002-2011

Despite the enhancement of the nitrogen emissions to the atmosphere and higher utilization of mineral fertilizers the country reports improvement in the water quality which could be related to the application of the EU directives at national and regional level. On the other hand it should be taken into consideration that the processes of the nitrogen cycle are progressing more slowly than in the West Europe [5]. Our soils are heavier, the processes not so active. It means that if now a trend to increase of the nitrogen pollution has not yet been observed it can appear in the future. This is much probable because the soils pollution is in effect, it is accumulated and its entering into the groundwater bodies is hardly avoidable.

Modeling of nitrogen loading of a groundwater body BG3G000000NQ018 and scenario analysis – outcomes of the project „Groundwater pollution assessment due to the agricultural land use with different rates of fertilizer application" 2011, NIMH, BAS

The agricultural lands of Bulgaria make 60% of the country territory. The Soil Institute "Pushkarov" regards 9 types of soil profiles as representative for the Bulgarian arable lands. On a field near the Tzalapitza village in Bulgaria after 18 years field experiments (1972-1990), made by the institute with maize production a fertilizer norm of 274 kgN/ha was established [5]. It makes possible the highest rate of acquisition of the nitrogen by the plant with yield of 10000 kg/ha of corn grain. These results and data availability made possible the performance of the numerical investigation envisaged in the above mentioned project.

The main objective of the investigation, based on employment of mathematical models is to show the possibility for achievement of good agricultural practices leading to "satisfactory yield – admissible pollution of the soil waters with nitrates – reduced nitrogen emissions". It is accomplished for the most sensitive to nitrate pollution soil type (fluviosoils) for which the above discussed norm of 276 kg N/ha was determined. With the fluviosoils the wash up of the nitrogen from the soil profile leads to its penetration into the groundwater and subsequently into the adjacent rivers.

The study was implemented by the mathematical model WAVE (Water and Agrochemicals in the Vadose Environment) which simulates simultaneously and with rather good realism several very complex natural processes taking place in the soil under the atmospheric effects [9]. They are the water, heat and chemicals transport through the soil profile, the evapotranspiration and the biochemical processes connected with the plants growth (the transformation of the nitrogen - nitrification, denitrification, mineralization, immobilization, adsorption and plant uptake).

The model approximation to the simulated processes was many times checked and was proved as good enough. For the concrete case study the model was calibrated in respect to several constants and validated for the climatic and soil conditions of the Tzalapitza experimental field through comparison with the averaged field data of the „N.Pouskarov" Soil Institute in Sofia.

Numerical simulations were caried out for 6 years period with maize production on the Tzalapitza test field at different rates of fertilizer application - 274 kg N/ha, 207 kg N/ha and 137 kg N/ha (respectively 100%, 75% and 50% of the max rate) with an average annual precipitation of 550 mm and different regimes of irrigation. The best regime *soil water-crop yield –safe groundwater* was achieved by fertilizer application 274 kg N/ha, where the crop reaches 11264 kg/ha maize and nitrate loading of the groundwater 11-22mg/l, bellow the recomended value of 25 mg/l. But the N emissions with this scenario exceed the admissible standards. The scenario with 207 kgN/ha shows 17% less N emissions and 20% less yield. It can be called as an "environmentally friendly" option. The environmental protection will cost some reduction of the agricultural production.

Detailed description of the results is given in [5]. Their analysis brings to the following general conclusions:

- the regarded processes in the soil, related to the land use and leading to groundwater contamination with nitrate and emission of nitrogen, are very complex and depending on the favorable concurrence of many factors and particularly the climate ones;

- the emissions and groundwater loading with nitrogen and the crop are narrowly linked and the problem of environmentally safe agricultural practices can not be solved without joint consideration of these components and assumption of compromising solutions;
- with a rational application of fertilizers, irrigation and other agricultural activities with current control of the soil moisture it is possible the achievement of acceptable from environmental and economical viewpoints results. The main goal should be to succeed the utmost exhaustion of the fertilizer by the plants.
- the model WAVE simulates fairly well the processes running in the soil and its surface with the plants growing and predicts the yields with good precision and could be employed as an effective tool for assessments in the agriculture for optional planning and seeking for good practices.
- the groundwater contamination depends on their depth and the soil water conductivity. That's why this problem stands in a different way in the various regions of a country. With shallow situated groundwater their contamination is inevitable and the fertilizers application should be reduced. Vice versa with deep groundwater such a possibility could be negligible and the restrictions in the fertilizer application could prove irrelevant.

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CROATIA

Leaching of NO_3-N in a drainpipe water influenced by different nitrogen fertilization treatments

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In a field trial with different mineral nitrogen doses (0, 100, 150, 200, 250 and 300 kg Nha^{-1}) nitrate nitrogen losses in drainage water are quantified for the period from October 1997 to December 2007. The trail was set up so that the area of each fertilizing treatment embedded two drainpipes, in their full length. Water samples were collected on a daily basis during the periods of outflow. NO_3-N concentration in drainage water varied in dependence on the crop type and development stage, on the fertilization, on the quantity and intensity of precipitation and on the drainage volume. Crop sequence at test field included corn, winter wheat, oilseed rape and soybean. Results can be used for prediction of nitrogen losses with drainpipe water in regions with similar agro-ecological conditions.

Leaching of nitrogen is influenced by the crop, duration of the period between two crops (highest leaching occurs on areas without crops), weather conditions, soil tillage, and above all by the quantity and type of fertilizers applied. The highest nitrogen leaching occurs during the autumn and winter period when precipitation exceeds evaporation and the plant intake is reduced to the minimum. In Croatia, Simunic et al. (1997, 2002) studied the NO_3^- and NH_4^+ concentration in drainage water. The lowest values of leached NO_3^- were recorded just before the seeding and fertilization - 11.7 to 27.0 mgL^{-1} of drainage water. The highest values were recorded in September primarily owing to extremely high precipitation in that month. Concentrations of leached NO_3^- were much above the tolerated 50 mgL^{-1}: 57 to 107.8 mgL^{-1} NO_3^-. Klacic et al. (1998) studied the effect of different pipe drainage distances upon the concentration and quantity of nitrogen leached in winter wheat production on hydromorphic soils of Sava River valley. Depending on the pipe drainage distance, leached nitrogen ranged from 11.0 to 21.7 $kgha^{-1}$. About 56% of total leached nitrogen originated from fertilizers added in basic and pre-seeding soil preparation. Investigation goal of our research was to determine the influence of different mineral nitrogen rates on NO_3^- N concentration in drainpipe water and on quantities of NO_3^- N leached.

The trail was set up so that the area of each fertilizing treatment embedded two drainpipes in their full length. Trial treatments were: 1.Check–unfertilized, 2. N_0 PK, 3. N_{100} PK, 4. N_{150} PK, 5. N_{200} PK, N_{250} PK, N_{250} PK + Phosphogypsum, N_{250} PK + Zeolite tuff + $CaCO_3$, 9. N_{300} PK and 10. Black fallow. NO_3^--N concentration in drainage water varied in dependence on the quantity of mineral nitrogen applied, on the quantity and intensity of precipitation, and on the drainage volume. In treatments without mineral nitrogen application, viz. in the check treatment and in the treatment fertilized with phosphorus and potassium, the average NO_3^- N concentration was relatively low. In the treatment involving black fallow, all tillage practices were the same as in other trial treatments, including also supplementary tillage practices. On experimental plots, crops were grown in the following crop sequence: 1995/96, 1998/99, 2003/04 and 2006/07 - maize (*Zea mays*), 1996/97, 1999/2000, 2002/03, 2005/06 and 2007/08 - winter wheat

(*Triticum aestivum*), 1997/98 and 2000/01 oilseed rape (*Brassica napus var. oleifera*), 2001/02 and 2004/05 soybean (*Glycine hispida max.*). The trial plot size was 30x130 m (3900 m^2) for each treatment, as conditioned by the drainpipe spacing and their length (130 m). Water samples were taken on a daily basis, and average sample was prepared every 5-7 days to be used for chemical analysis of water.

The experimental station soil type is defined as Stagnosols, with $A_{ch}+E_{cg}$ – E_{cg} – B_{tg} sequence of soil horizons. Due to its physical (high content of fine sand, silt and clay) and chemical properties (calcium deficiency, low content of organic matter), this soil type has limited fertility. Intensive mineral fertilisation is very important for arable farming at given conditions. Because of water stagnation in soil profile drainpipes were installed at the average distance of 20 m.

NO_3^- N concentration in drainage water varied in dependence on the quantity of mineral nitrogen applied, on the quantity and intensity of precipitation, and on the drainage volume. In treatments without mineral nitrogen application, viz. in the check treatment and in the treatment fertilized with phosphorus and potassium, the average NO_3^- N concentration is relatively low. Increased rates of applied mineral nitrogen led to higher average values of NO_3^- N concentration in drainage water. At the treatments with 100 and 150 kg ha^{-1} N, average nitrate nitrogen concentration was lower than 15 mgL^{-1}. At the treatments with higher doses of nitrogen, concentrations of NO_3^- N in drainage water were also higher, and they were in relation with quantities of applied nitrogen. Maximum average concentrations went up to 27,2 mgL^{-1} NO_3^- N at treatment with 300 kg ha^{-1} N. Similar results were attained by Klacic *et al.* (1999) and Simunic *et al.* (2002). During months when discharge volume was bigger, average nitrate nitrogen concentration decreased, but differences between trial treatments remain similar.

Average nitrate nitrogen leaching in drainpipe water from treatments 1 and 2 where crops were grown without mineral nitrogen fertilization varied from 6.1 to 8.0 kg per hectare. Compared to that, average nitrate nitrogen leaching at black fallow treatment was higher – 8.6 $kgha^{-1}$. Nitrate nitrogen leaching in drainpipe water from treatments with mineral nitrogen fertilization varied from 8.1 $kgha^{-1}$ at the treatment with 100 $kgha^{-1}$ N up to the 29.7 $kgha^{-1}$ at the treatment with 250 $kgha^{-1}$ N and phosphogypsum. Compared to the average quantity of nitrogen applied, average quantity of nitrogen leached in drainpipe water from different trial treatments varied from 8 to 12% of applied mineral nitrogen.

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CROATIA

Water quality of the river Sutla and possibility of river restoration

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Introduction

River Sutla (Sotla) forms the border between the Republic of Slovenia and Republic of Croatia. The size of the Sutla (Sotla) river basin is almost 600 km2. The Vonarje reservoir of 12.4 million m3, as a part of the nature retention of the Sutla river basin and the artificial lake behind the Vonarje dam, was built and filled in 1980. The main purpose was drinking water supply for both, Slovenian and Croatian settlements and flood protection of downstream areas.

Shortly after filling, water in the reservoir became eutrophicated. Besides, other extreme water quality problems have been detected not only in the lake water but also in the river water downstream. Due to high risk to human and environmental health that has been hardly been managed successfully. In the absence of better remediation measures the reservoir was completely drained in 1988. and now operates only as a dry retention basin for flood protection. In the bottom of reservoirs wetland ecosystems developed. This has been the reason that the area of the reservoir on the Slovene side has been declared also as Natura 2000 site.

In the course of the past decade, the area of the Sutla (Sotla) catchment has been touristic developed catchment. At present, there are many local and regional initiatives to fill the Vonarje reservoir with water again and develop touristic and recreational facilities along its shore. There are also initiatives to use water for irrigation and drinking water supply. Both Slovenia and Croatia, being the new EU Member State, are now faced with the great challenge to achieve not only the good ecological and chemical status of the Vonarje lake and the river Sutla (Sotla) (as directed by Water Framework Directive), but also to achieve good or excellent quality for bathing and protection from adverse effects of water. Furthermore, both have also to harmonise touristic, recreational, fishing and irrigation needs at the same time. But firstly, they have to guarantee that emissions from urban areas and due agricultural activities in the catchment are reduced and managed accordingly. The river basin management plan of the Sutla does not exist, but some problems related to water management can be solved by the multilateral activities and Slovenian – Croatian Commission.

Due to implementation of the European industrial and urban waste water treatment legislation and environmental agricultural policy on both side, in Slovenia and Croatia (becoming a new EU member State in 2013), emissions to water and risk to water quality in the Vonarje reservoir are expected to be much lower in future then in 1980's. Nevertheless, past pollution residuals in the bottom of the lake, pollution due higher traffic, pressure to water environment from fisheries, touristic and recreational facilities, agricultural activities are intensified and expected changes of climate patterns do not necessarily support this expectation. Furthermore, the users of the catchment on the Slovenian and Croatian side are a bit different. On the Slovene side, there is more industry, "industrial like" tourism (large congress, thermal and wellness facilities) and larger urban areas. On the Croatian side, the users in basin are mainly engaged in traditional agriculture. The water uses are less intensive. Waste water collection and treatment depend on settlement patterns and differ in technologies applied.

Both EU countries, Slovenia and Croatia, are expected to apply for new development and cohesion funds to develop environmental and other infrastructure in the catchment. It is important that in the water management we take into account two national institutional systems and different past two decades economically developments: Though there are strong cultural ties between local communities on both river sides, the challenge for catchment water quality management to secure good ecological and chemical status of the Sutla river today is therefore even greater that it has been in the past.

For this purpose, it is necessary to know the catchment hydrological and hydraulically characteristics, sources of pollution, pollutants flow, various chemical parameters decomposition patterns and existing aquatic ecosystem ecology. Only then we might be able to analysis pollutant's impacts on aquatic ecosystems and quantify water quality parameters under different development scenarios. Getting knowledge of these processes is crucial for proposing remediation measures and setting economically sound environmental protection management measures.

To face these challenges we developed conceptual water quality management model for the catchment. It should initiate common approach for both countries to control water quality on catchment level and manage aquatic ecosystem to fulfilling environmental goals.

1. CONCEPT OF WATER QUALITY MANAGEMENT

Metodology for water quality modelling of the Sutla (Sotla) river is built within the DPSIR framework. For each DPSIR module specific datasets and/or according to the requirements of the Water Framework Directive, indicators should be developed as presented in
Table 1, but the research of the Sutla river basin will evaluated from static reporting framework to dynamic modelling environment, from environmental to multi- disciplinary approach.
For each cluster we collected all available data for as much a possible long time period. The sources are results of national monitoring systems, statistical census and registers. When as much as possible data are collected, data on pressures and states are interpreted. We have focused our research on eutrophication and organic pollution.

Driving forces and pressures indicators

Most of the population lives in small rural settlements. On the Croatian side of the Sutla river population lives in 67 smaller settlements with almost 17,000 inhabitants in total. Administratively they are organized in eight counties. Structured information of driving driving forces and pressures are presented in Table 1.

Table 1: Driving Forces/Pressures on the Slovenian and Croatian side of the Sutla river catchment.

<table>
<tr><th></th><th>Catchment on the right side of the Sutla (Sotla) river, Slovenian part</th><th>Catchment on the left side of the Sutla (Sotla) river, Croatian part</th></tr>
<tr><td>Surface of the catchment area</td><td>459.9 (78% of the whole)</td><td>130.7 (22% of the whole)</td></tr>
<tr><td>Driving forces:</td><td>Tourism and recreation (wellness, spa, one one-day), protection of cultural and natural heritage (park, protected monuments), traffic, agriculture, industry</td><td>Agriculture, protection of cultural and natural heritage, traffic</td></tr>
<tr><td>urbanisation:
Number of settlements by range of number of inhabitants</td><td><table><tr><td colspan="2">Number of :</td></tr><tr><td>inhabitants</td><td>settlements</td></tr><tr><td><100</td><td>33</td></tr><tr><td>101-500</td><td>47</td></tr></table></td><td><table><tr><td colspan="2">Number of:</td></tr><tr><td>inhabitants</td><td>settlements</td></tr><tr><td><100</td><td>21</td></tr><tr><td>101-500</td><td>41</td></tr></table></td></tr>
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<tr><td></td><td><table><tr><td>501-1000</td><td>1</td></tr><tr><td>1001-1500</td><td>0</td></tr><tr><td>>1500</td><td>3</td></tr><tr><td>Total</td><td>84</td></tr></table></td><td><table><tr><td>501-1000</td><td>3</td></tr><tr><td>1001-1500</td><td>1</td></tr><tr><td>>1500</td><td>1</td></tr><tr><td>total</td><td>67</td></tr></table></td></tr>
<tr><td>Two largest urban areas and number of inhabitants</td><td>Rogaška Slatina: 4800
Šmarje pri Jelšah: 1600</td><td>Klanjec: 3230
Hum na Sutli: 1240</td></tr>
<tr><td>Population</td><td>38139*</td><td>16700</td></tr>
<tr><td>Population density</td><td>85 inhabitant / km²</td><td>120 inhabitants / km²</td></tr>
<tr><td>Land use**</td><td><table><tr><td></td><td>km²</td><td>%</td></tr><tr><td>Agriculutral land:</td><td>285.3</td><td>62</td></tr><tr><td>Forests</td><td>167.1</td><td>36.3</td></tr><tr><td>Inland wetlands</td><td>0.7</td><td>0.2</td></tr><tr><td>Urban, Industrial, commercial and transport units</td><td>4.6</td><td>1.0</td></tr><tr><td>Total</td><td>459.9</td><td>100</td></tr></table></td><td><table><tr><td></td><td>km²</td><td>%</td></tr><tr><td>Agriculutral land:</td><td>85.6</td><td>65</td></tr><tr><td>Forests</td><td>28.8</td><td>22.0</td></tr><tr><td>Inland wetlands</td><td>0.2</td><td>0.2</td></tr><tr><td>Urban, Industrial, commercial and transport units</td><td>2.8</td><td>2.1</td></tr><tr><td>Total</td><td>130.7</td><td>100</td></tr></table></td></tr>
<tr><td>Agriculture:</td><td><table><tr><td></td><td>km²</td><td>%</td></tr><tr><td>Arable land</td><td>14.0</td><td>3.1</td></tr><tr><td>Heterogeneous agricultural areas</td><td>229.7</td><td>49.9</td></tr><tr><td>Pastures</td><td>39.6</td><td>8.6</td></tr><tr><td>Permanent crops</td><td>2.0</td><td>0.4</td></tr><tr><td>Scrub and/or herbaceous vegetation associations</td><td>2.2</td><td>0.5</td></tr><tr><td>Total</td><td>285.3 km²</td><td>62% of total land</td></tr></table>rural population: 10% of the population; the main agricultural activity: livestock; farms are fragmented;</td><td><table><tr><td></td><td>km²</td><td>%</td></tr><tr><td>Arable land</td><td>0.1</td><td>0.1</td></tr><tr><td>Heterogeneous agricultural areas</td><td>59.2</td><td>45.3</td></tr><tr><td>Pastures</td><td>26.3</td><td>20.1</td></tr><tr><td>Permanent crops</td><td></td><td>0.0</td></tr><tr><td>Scrub and/or herbaceous vegetation associations</td><td>13.4</td><td>10.2</td></tr><tr><td>Total</td><td>85.6 km²</td><td>65% of total land</td></tr></table>rural population: 30% of the population; the main agricultural activity: vineyards, livestock; farms are fragmented;</td></tr>
<tr><td>Industry/Enterpreneurship and Tourism/Recreation</td><td>Glass manufacturing; sparkling water - drink production; 250 small enterprises (commerce, consulting, banking, construction services)</td><td>Industrial facilities in Hum na Sutli, crafts and manufacturing in Klanjec,lLivestock farming and slaughterhouses in Gornji Čemehovec</td></tr>
<tr><td>Tourism/Recreation/Parks</td><td>Health Center Rogaška Slatina; Spa Center Olimje; Regional park Kozjansko; Landscape parks Boč and Jovsi;</td><td>Ethno village Kumrovec</td></tr>
</table>

State and impact indicators

The average annual precipitation in the Sutla (Sotla) river catchment is 1200 mm, evapotranspiration counts about 650 mm. The Sotla River has the Pannonian flow regime with two identical peaks, one in early spring and the other in late autumn. Low flows occur in summer and winter. August has the lowest discharge.

On the Sutla (Sotla) river there are seven monitoring locations of water quality, four in Croatia and three in Slovenia Water levels and discharges are monitored on six locations. On the Sutlansko jezero there are data for discharges available only for one year (2009). Water quality trends as presented by quality classes (from first to fifth) for three clusters of parameters, oxygen regime, nutrients and biological indicators are presented in Figure 1. One can observe that due nutrients water downstream from Prišlin before 2012 has been mainly classified not better than third class. The exception is Lupinjak, where nutrients have not posed any significant problems. Due oxygen in water at Zelenjak and Harmica water quality was in second or third class, but at Prišlin it is in third class from 2004 on. It has been even in fifth class form 2000 to 2002. By biological indicators, water along the Sutla (Sotla) river is more or less steady, having second class classification. The deviation of oxygen regime of monitoring stations Zelenjak in 2005 and Prišlin in 2007 is associated with the water temperature, which has a major impact on dissolved oxygen, and oxygen saturation. For example, in the summer when the air temperature recorded high water above 25 ° C, the amount of dissolved oxygen are minimal, while in winter when the water is much colder, and records the temperature averaged about 5°C, dissolved oxygen concentrations are high. By evidence, the recorded high concentrations of COD in these years, amounted to more than 25 mg O2/l, while the minimum monthly flows was less than 1m3/s. Large concentrations of BOD5, also, occurred in 2001 at Harmica (24 mg O2/l) while the flow was 1.15 m3/s .

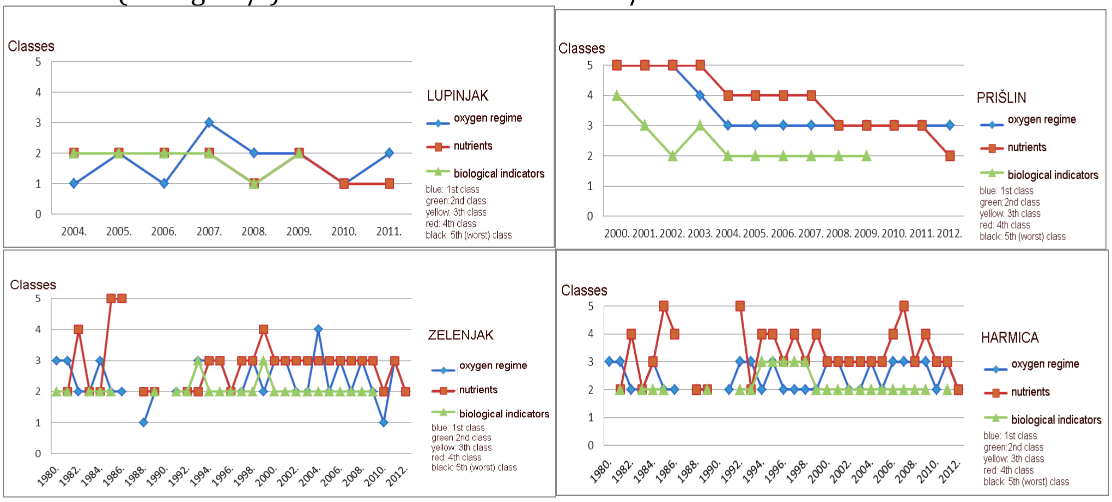

Figure 1: Trends of water quality classes for four monitoring stations in Croatia

First results from analysis showed that there is still significant input of nutrients into the Sutla (Sotla) river present. The reasons are untreated urban waste water, surplus of nitrogen applied on agricultural land (to be modelled in future) and unfavorable oxygen conditions due high temperatures and low water flows (water quantity problem). The eutrophication risks and risk of the presence of fecal bacteria in the water are high. Agricultural activities may also lead to increased concentrations of suspended solids, pesticides, herbicides and salt in water.

Responses

In Slovenia, the programme for waste water treatment following Urban Waste Water Treatment Directive (UWWTD) has been implemented since 2004 and in Croatia since 2010. Furthermore, the Cohesion, Structural and Environmental - Agricultural Funds from European Union have been used in reduce impact of waste water pollution and pollution due agricultural activities to water resources.

CONCLUSIONS

Summarizing our analysis conducted for the Sutla river basin, a generalized DPSIR model has been prepared with particular focus on water quality and eutrophication. Agriculture (livestock), urbanisation (waste water) and flow alterations are among serious driving forces exerting pressures on the aquatic system altering also its biodiversity. River restoration in therms of revitalisation role of nature retention in water quality management and the implementation of site-specific ecological requirements is thus urgently needed, specially related to nature protection areas and recreation resorts.

The past common practice of the overexploitation of river water for various - usually competent- uses should be limited especially under the light of climate change and extremelly dry and wet periods. The rising need for development should be coincided with environmental policy avoiding overexploitation of natural resources including protection of aquatic resources.

The Sutla (Sotla) river is a national border between Croatia and Slovenia, but neverthelles the important bridge linking inhabitants on both side of the river that live together for centuries. The prerequisite for successful water management of this border river is better co-operation between Croatia and Slovenia. The importance of controlling pollution sources confirmed the negative experiences from 1988, when the Vonarje lake (water in accumulation) have been heavily eutrophised and emptied therefore. The donwstream quality has deteriorated for years because of this release. The increasing hydrological extremes point to greater need for the integreted river basin management that include construction of retention on the upper part of the river basin (Slovenian) to protect downstream parts of river basin (Croatian and Slovenian).

ITALY

Cross comparison of nitrogen sources, sinks and transport within river basins: the Italian Nitrogen Network initiative (INN)

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Nitrogen deficit or excess within ecosystems imply different problems. The shortage of this key nutrient strongly affects agricultural productions while its abundance ("too much of a good thing") determines water eutrophication and associated setbacks. Nitrogen is for these reasons a central subject of the scientific research of different disciplines and an impressive number of studies were produced in the last decade. At the beginning of 2014 a national initiative was launched to link researchers dealing with nitrogen, including limnologists, ecologists, biologists, agronomists and hydrogeologists. The initiative (INN, Italian Nitrogen Network) consists in sharing a common methodology to evaluate the nitrogen budget at the watershed level. Specific meetings were organized to share and discuss a common method for data collection and budget calculation (Oenema et al., 2003). Most necessary data can be free downloaded from national statistical databases and have the municipality resolution. They include agricultural productions in terms of surfaces, typologies and amounts of farmed animals. All input data are converted into nitrogen units by means of site-specific, appropriate coefficients. An inventory of input (n associated to manure, synthetic fertilizers deposition, biological fixation) and output terms (crop uptake, ammonia volatilization, denitrification in soils) is produced and a net budget is calculated across the agricultural lands. As for most Italian rivers water flows and hydrochemical data at the closing sections are available, N export from each basin can be computed and compared to the budget. This, together with detailed knowledge of accessory information (e.g. population density, land use, slopes, presence of wetlands, soil permeability) allows to infer about the system capacity to metabolize N loads and its relevance in planning appropriate management actions. At present some budgets are already available (Oglio, Mincio, Volano, Agogna, Parma, Secchia, Adda, Panaro), while others are in progress (Adige, Reno, Tevere, Scrivia, Alento, Lambro, Olona, Ticino, Enza, Crostolo, Arborea Plain, Venice Lagoon Basin). We present here the initiative, the aims, material and methods, the investigated watersheds and the perspectives.

ITALY

Nitrogen budget in the Po di Volano watershed (Po River Delta, northern Italy): new insights on nitrogen removal via denitrification in the secondary canal network

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Detailed studies on pollutants genesis, path and transformation are needed in agricultural catchments facing coastal areas. The Po di Volano (sub-basin of the Po river in northern Italy) is a deltaic area close to a network of eutrophic lagoons of particular interest for biodiversity and ecosystem services. Main features of this basin are extremely flat topography and fine soil texture, intensive agriculture, mainly sustained by chemical fertilizers and with scarce relevance of livestock farming and the extended network of artificial canals where previous scientific evidences have proven a notable removal of the excess nitrogen. A soil system N budget was calculated evidencing an average nitrogen input exceeding output terms by 60 kg N ha-1 year-1, a relatively small amount if compared to sub-basins of the same hydrological Po River system. The analysis of dissolved inorganic nitrogen in groundwater and nitrogen mass balance in surface waters provided evidences of efficient control of the nitrogen excess in this geographical area where denitrification in soil and in the secondary drainage system appears to be the most relevant ecosystemic function. To further investigate the importance of denitrification in vegetated and unvegetated secondary canals, measurements were performed in 2013, at the whole reach scale. The method (Laursen and Seitzinger, 2004) is based on the changes in dissolved N_2:Ar, measured by mean of a Membrane inlet mass spectrometer (MIMS). Results evidenced that in vegetated ditches the rates of denitrification were on average one order on magnitude higher than in unvegetated canals and nitrogen removal via temporary storage in the plant biomass was two order of magnitude lower than denitrification. The study highlights the importance of actions aiming to minimize nitrogen pollution in impacted watershed using low cost management practices based on the effectiveness of emergent vegetation.

MOLDOVA

Managing nitrogen and phosphorus loads to water bodies: Characterization and solutions (Republic of Moldova)

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I. Water Bodies of Moldova. Compared to Europe and neighboring countries (Romania and Ukraine), Moldova is a country with few resources of water. The factors explain the modest water reserves in Moldova: insufficient humidity, plains and plateaus, landscape and topography, other physical-geographical factors. Backwaters surface water volume and river flow rate is low. River network density is 0.48 km/km^2. The hydrographic network is represented by 3621 rivers and streams. Brief length of rivers is greater than 16 thousand km.

Rivers. The rivers belong to the Black Sea basin. Predominant small rivers. Among the biggest are two transbondary rivers: Dniester -1352 km (inside the country - 657 km) and Prut - 976 km (inside the country - 695 km). The main rivers in the inside of country: Răut - 286 km; Bîc – 155 km. The main supply sources of rivers are *snows and rains*, the role of groundwater is much lower. This feeding characteristic causes the maximum level of the rivers in spring and summer season, with torrential rains, river levels, especially the smaller ones, may rise considerably, sometimes causing flooding and pollution. After its specific rivers can be grouped as follows: *Dniester rivers basin*; *Prut rivers basin; Southern rivers flowing into Danube and/or Black Sea Basin.*

Lakes. There are few natural lakes. Most of them are in the floodplains of the rivers *Prut* (Beleu, Rotunda, Foltane), *Bic, Cahul, Cuciurgan.* But the number of artificial lakes is large (over 3500), built to supply to water the hydropower, irrigation, fishing, industry and human settlements.

Groundwater. In Moldova there are also over 2200 natural water springs. About 20 mineral deposits with over 200 springs were identified and explored. The most valuable is considered curative mineral waters containing components as sulfides, iodine, bromine, boron and radon.

Drinking water. In Moldova, about 40% of the population (rural) is supplied with water from underground layers with hydrostatic pressure and first aquatic layer without pressure. These types of groundwater occur for whole territory of Moldova.

II. Pollution Sources of Water Bodies – N & P: Agriculture - Erosion – Wastewater.

Water pollution by nitrates and phosphates occurs more locally than at the territorial level. But the consequences can lead to intensification of the Black Sea basin and Danube lagoon pollution. The main aspects of Water Bodies pollution by N & P caused by agricultural activities in Moldova can be summarized as:

1. The use of chemical fertilizers (especially nitrogen) in doses too large and uncorrelated with consumption in different stages of crop development. Often, their application is made on the frozen ground and thick snow layer, in which case, the sudden melting and favored by slope, reach, washing in water bodies used as sources of drinking water.

2. Wastewater discharge, untreated or incompletely treated, from livestock complexes in surface waters. Wastewater infiltration depth during storage in ponds and pools, affecting the quality of groundwater used as a source of drinking water in many rural areas.

3. Use for agricultural land fertilization and irrigation, the wastewater sludge from livestock farmers, content with harmful salts and pathogens, including large amounts of nitrates and phosphates.

4. Administration on agricultural lands adjacent to livestock rearing, the exaggerated manure norms (100 t/ha) at intervals of 2-3 years, that far exceed the needs of plants and causes the accumulation of nitrates in feed and nitrate leaching in groundwater.

5. Uncontrolled livestock manure storage and lack of accumulation pools for liquid fraction of manure in private households have negative effects as leaking in flowing water and groundwater nitrate infection.

6. Aggravation of soil erosion on slopes due to improper agricultural practice systems: a faulty organization of the territory, works the soil from the hill into the valley, crop rotations with a high proportion of plant hoe, without organic fertilization.

7. Degradation of soil physical status (structure, porosity, permeability, resistance to plowing) due to lower organic matter content and excessive traffic on agricultural land, insufficient soil humidity.

Achievements. Moldova has *the largest treatment plant from Europe* (Orhei). It is constructed on the basis technology “Constructed Wetlands“, filtered daily amount between 1400 and 1500 cubic meters of waste, with a maximum capacity of about 4000 cubic meters. Now in rehabilitation stage are 156 plants.

Agricultural Pollution Control Project (2005 – 2010).

Objectives: - to reduce N & P pollution of the Danube and Black Sea Basin from agricultural activities; - promote the adoption of environmentally friendly practices in the cultivation of crops and maintenance of animals that contribute to nutrient pollution, including management of watersheds and wetlands; - strengthen the national capacities and regulatory in nutrient pollution and organic farming; - promote a wide awareness campaign and strategy.

ECO-AGRI Project - Sharing Collectively the Competences of the researchers to the Farmers for a Sustainable and Ecological Exploitation of the Agricultural and Environment protection (2013-2014). www.ecoagri.ecomct.ro.

Overall objective (long term effects): to bring a contribution through commune effort of the partner for a sustainable development in the project areas, through actions for improving the agricultural practices and awareness on reducing chemical fertilizers uses.

III. Conclusions:

1. ***Organized sources of water pollution*** include municipal, industrial and agricultural wastewater. These sources are known and monitored, and their discharges can be estimated with sufficient accuracy.

2. ***Unorganized sources of water pollution*** include filtering fields of sugar factories, sludge storage on the drying platforms of treatment plants and manure from livestock complexes remaining in operation. Unfortunately the impact of these sources of water pollution are not monitored. Missing network observations and laboratory investigations on groundwater from the site of the mentioned objectives. Lack of systematic factual data does not allow meaningful assessment of the situation, followed by measures to combat pollution which causes further degradation of surface and ground water quality.

Solutions to prevent N & P water pollution:

The current conditions of nutrients pressures and impacts in Moldova, obligated us:

- to assess the nutrient content of agriculture through network monitoring and modeling methods, scenarios of impact of land use and climate changes,

- to perfect the institutional and legislation context regarding nutrients management;

- participate in the transboundary collaborations, implementation strategies and programs of measures already in place;

- development and implementation of measures to prevent and combat land degradation and environmental pollution by nutrients from agriculture.

Transboundary pollution: Transboundary water management involves common efforts of neighboring countries (Moldova - Romania, Moldova - Ukraine) and is regulated by international conventions. Among these are:

- Convention on the protection of transboundary rivers and international lakes (1992);

- Convention on Cooperation for the Protection and Sustainable Use of the Danube River Basin (1994).

Other legislation:

- WATER CODE OF THE REPUBLIC OF MOLDOVA (no. 1532 of 22.06.1993).

- Law on drinking water. 272 of 10.02.1999.

Water Law. 272-XVI from 23.12.2011

We are always ready to collaborate together in research joint projects for a favorable environment and healthy lifestyle.

MOLDOVA

Managing phosphorus loads to water bodies. The case of the Hydrographical Basin of the Prut River (Republic Of Moldova)

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Phosphorus is the important nutrient which stimulates the growth of aquatic organisms in water bodies, but in excessive quantities phosphorus has a fertilizing effect that affects both the ecosystem and water quality as whole. Eutrophication is a complex process that occurs in natural waters, when certain types of algae grow excessively and become a threat to human health. The primary cause of eutrophication is the high concentrations of nutrients in the aquatic environment. The term "eutrophication" began to be used for conservation of the good ecological status of water, for example, in the European Directives, which is defined as "accelerated growth of algae and higher forms of vegetation caused by the enrichment of water by nutrients, particularly, compounds of nitrogen and/or phosphorus, inducing an undesirable disturbance of the ecological balance in the reservoirs"[1].

The Prut River, a Danube tributary, is a transboundary river at the centre of Europe. Hydrographical basin has surface about 27 500 km^2 of which on the territory of Ukraine - 9500km^2, Romania - 9760 km^2 and Moldova - 8240 km^2 [2]. The Prut River has length of 967 km, of which 695 km on territory of Moldova.

Phosphorus is presented in surface water naturally (as a result of the mineralization process of vegetable and animal residue) or due to anthropogenic pollution: diffuse sources from agriculture, untreated or insufficiently treated municipal waters and the use of polyphosphate detergents.

The discharges of untreated or insufficiently treated wastewater from sewage plants have a significant influence on the quality of natural waters. According to data presented by National Bureau of Statistics [3], during of 2006-2010 years in the Republic of Moldova a reduction of the quantity of wastewater discharges has been recorded (from 695 mln m^3 to 681 mln m^3, Table 1). However, due to insufficient functioning wastewater purification plants, the content of pollutants discharged in the natural waters often exceeds the limit allowed by the environmental authority. Urban wastewater are containing the suspended solids, organic matter, nutrients, and other pollutants like heavy metals, detergents, petroleum hydrocarbons, organic micropollutants, in dependence on the types of existing industry and the level of pre-treatment of industrial water [4].

The large industrial cities from Moldova, Ukraine and Romania are localized in the hydrographical basin of the Prut River. Along the Prut River there are many cities, as Cernauti (Ukraine), Ungheni and Cahul (Moldova) Saveni, Iasi, Husi, Galati (Romania), therefore its water quality largely depends on human influence. In the urban waters of these cities, which are discharged into the Prut River, the content of some indicators, like suspended solids, ammonia, organic matter, total nitrogen, hydrogen sulphide and total sulfur, including phosphorus, is often exceeds the allowed value [4]. During of 2009-2012 years, the content of phosphorus was generally higher in the stations downstream cities along the Prut River [5], which is caused by urban waters discharged in the river.

The impact of waste on the water quality has increased alarmingly in recent years. Their mismanagement generates the contamination of soil and groundwater and emissions of methane, carbon dioxide and toxic gases with direct effects on the human health and the environment [6].

Table 1. Volume of water discharged in the natural reservoirs (million m^3).
Data are presented for Republic of Moldova [3]

Discharged waters	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Discharged waters - total	695	687	686	685	691	686	681
Conventional pure waters (without treatment)	562	551	550	552	556	555	553
Polluted waters	7	10	14	10	8	8	9
… without treatment	0	1	1	1	1	1	2
… insufficiently treated	7	9	13	10	7	7	7
Regulatory treated waters	119	119	115	116	119	115	113

People from rural areas on the territory of Moldova often do not know the dangers of poor management of waste (mixing all types of waste - animal, chemical, construction, metal, etc.) and have tossed them on the banks of kidnap and near springs, which causes heavy pollution of ground and surface waters [6].

The most deposits on the territory of Moldova are overloaded and unsupervised of responsible persons. Some waste is stored outside of the attributed areas, so extending in this way the deposit surface. In many places the deposits aren't arranged. According to data provided by the State Ecological Inspectorate of Moldova, the appearance of approx. 3000 unauthorized dumps have been annually recorded and their number is more than the liquidated ones [6].

In order to increase the agricultural production, any kind of fertilizers, applied rationally, constitute premise for maintaining and enhancing of soil fertility. But the fertilizers can cause the disruption of the ecological balance, if used without taking into account the nature of soils, concrete weather conditions and plant needs.

In surface water the concentration of dissolved phosphate varies closely with the variation of their concentration in the soil [7]. Due to strong leakage [8], the increase of phosphorus in natural waters from areas with intense agricultural activities can be recorded.

According to the National Bureau of Statistics [3], on the territory of Republic of Moldova the total land area is 3.38 million hectares, of which agricultural land - 2.5 million hectares (73.8%), forest resources - 463.1 million hectares (13.7%). Of the total of 2.5 million hectares of agricultural land, the arable land is 1.81 million hectares (72.6%), orchards - 133 300 hectares (5.3%), vineyards - 149 600 hectares (6.0%), pastures - 350 400 hectares (14.0%).

During of 2006-2011 years, on the territory of Republic of Moldova, there was recorded an increase in the quantities of fertilizers used (Table 2). In comparison with data registered in 2006, the content of phosphate fertilizers used in 2011 increased by 52%.

Conclusions

Environmental objectives set out for assessing the level of eutrophication in natural waters, allowing minimizing eutrophication arising from human activities, are (i) reduce/prohibit the use of phosphate-based detergents; (ii) improving agricultural practices to reduce nitrogen and phosphorus pollution, and (iii) upgrading of treatment plants.

Since the water pollution of the Prut River is caused by household utilities (sewage treatment plants, discharges of untreated municipal wastewater, inadequate solid waste management), there is proposed to be undertaken the measures to improve the activity of water treatment plants, to liquidate unauthorized dumps from the rivers hydrographic basin and/or to improve the sewage systems and waste collection.

Table 2. Chemical fertilizers used on the territory of Moldova, according to the National Bureau of Statistics [3]

	2006	2007	2008	2009	2010	2011
Chemical fertilizers (the active ingredient) - total, thousand tons	15	20	23	17	20	24
of which: nitrogenic	13	17	20	15	16	19
phosphatic	1.9	2.0	1.7	1.6	2.4	2.9
potassic	0.7	1.0	1.1	0.8	1.3	1.5

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MONTENEGRO

National conditions and activities on managing nitrogen and phosphorus load to water bodies in Montenegro

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Conditions

The quality of waters in Montenegro is generally considered to be relatively good. It is observed by 36 monitoring stations on water courses, on 11 lakes and 16 on the Adriatic coast. Observation of quality and water regime performs the civil service, the Institute for Hydrometeorology and seismology of Montenegro. Longtime lack of groundwater monitoring is cut off before two years, when the observation of several wells in the Zeta Plain has been restored. The measurement results are compared with the legal classification (whether the quality of water is in the prescribed class), and annually distributed to all institutions.

Nutrients load to water bodies in Montenegro has two main causes: the discharge of untreated communal wastewater into water courses and rinsing of nutrients from agricultural areas.

The first is the major. In the present, only two of 22 municipalities in Montenegro have a wastewater treatment plant. Waste waters from other urban systems are discharged directly into rivers. This represents by far the most dramatic source pollution. But thanks to high-speed and low-temperature water in the most rivers, the concentration decreases relatively quickly and lakes are not particularly polluted. Although positioned downstream from the capital Podgorica with 1/3 of the total population, The Skadar Lake has last year shown a good water quality at depth to 1 m. (The systemic testing is done in the framework of a cross-border GIZ project on biodiversity in the Skadar Lake.)

Nutrients from agriculture - because of the concentration of agriculture in the plain landscapes - are most commonly identified in the groundwater observation wells (Zeta plain is the largest agricultural area in Montenegro).

Problems

Question of managing nitrogen and phosphorus load to water bodies does not belong to the systemic solved issues in Montenegro. In the government structure the competence is divided between two ministries:

- Ministry of Sustainable Development and Tourism (competence for environmental protection and utilities) - in its structure also Institute for Hydrometeorology and seismology of Montenegro, the Environmental Protection Agency and the communal infrastructure sector
- Ministry of Agriculture and Rural Development (competence for water management, monitoring of water regime, water issuing permissions), in its structure also the Directorate for Water and the Directorate for Forests.

The complete water sector is characteristic by a lack of staff and weak commitment to address this issue.

Also in the inspection services only two persons serve as water inspectors.

Apart data on water quality, information on the complete process, causes and regime is missed. Data are not space-referenced, there is no Water information system or a system that displays water bodies and the relevant data in space. This makes the process of analysis and identifying the responsible entities difficult.

Characterization of water bodies has not been done. Montenegro has no river basin management plans or other similar updated document. Water management is not working on the principle of the basin as the basic unit.

The process of water permits issuing is ineffective and missing the possibility of review. Data is stored in analog form, without space reference. It is not possible to clearly identify the relationship of emitters and water bodies in the basin.

The legislation recognizes two types of water bodies: the water bodies with importance for the state, and other water bodies. For the water of importance water permits are issued in the Directorate for Water of Montenegro. Other water bodies are under the competence of local governments. Data on the water permissions are not collected in a central database, or in databases of specific catchment areas, so that there is no complete information in one place. A similar division of the competence is prescribed also for hydroengineering objects by its capacity (ponds, irrigation systems etc.).

The pollution is charged, but the collected funds are only in a small portion returned to the water sector.

Current legislation allows the pollutant to pay less if treats the wastewater to the prescribed quality, or more if there is no data on quality of discharged water. Almost all pollutants choose the second option.

Solutions

In the utility infrastructure sector there is a significant progress in planning the construction of wastewater treatment plants in recent years. In three municipalities such facilities are under construction, and in the next few the documentation is being prepared. The continuation of the current trend would bring the rehabilitation of wastewater problems for a large majority of the Montenegrin population - and therefore of the biggest cause of nitrogen and phosphorus load to water bodies.

Ministry of Agriculture and Rural Development has recently adopted a so-called. Code of Good Agricultural Practice. It is not obligatory for all farmers. But it is going to be required for agriculture in vulnerable areas. The Ministry brings amendments to the Water Law this year. Among other issues, in the law is added also this obligation. However, the identification of vulnerable areas is not yet done.

Making the process of water permissions issuing more efficient and clear is yet not in the focus. Activities on the establishment of Water information system and its connecting to the environmental sector are at the very beginning.

River basin management plans, which would also treat this issues, are in the process of finding funds for their preparation. Similarly the delineation and classification of water bodies.

ROMANIA

Managing nitrogen and phosphorus loads to water bodies: Romanian experience

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Elvira Marchidan - PhD Engineer

It is known that water resources are subject to different anthropogenic pressures as result of human activities such as discharges of untreated or unproper treated municipal and industrial wastewaters, intensive agriculture and extensive farming, hydromorphological alterations and other pressures and related activities.

An assessment of the surface and groundwater bodies susceptibility to different type of pressures was carried in 2004. This was an intermediate step in identifying the water bodies at risk of failing the environmental quality objective of surface and groundwaters laid down in the Water Framework Directive 2000/60/EC (WFD). The risk analysis was updated in 2013, for the second RBMP (2015-2021) purpose. The methodology applied and used by Romania in this analysis took into account the identification of significant anthropogenic pressures, assessment of impacts of those significant pressures and identification of water bodies at risk of failing to achieve environmental objectives of the WFD.

The concept of DPSIR (Driver-Pressure-State-Impact-Response) is the basis of this type of analysis. A pressure is considered significant when this lead to the failure of the WFD environmental objectives for the water body of concern.

The entire analysis help in designing robust monitoring programmes and establishing appropriate programme of measures with the final goal of reducing pollution and ensuring the WFD environmental objectives.

Based on this, nutrients pollution has been identified as significant water management issue at the national level and the Danube basin-wide level. The nutrients emissions are generated by point sources (urban waste waters, industry and agriculture) and also by diffuse sources (due to the lack of wastewater collection systems for some agglomerations, especially in rural area and also from agriculture like farms, use of fertilizers).

MONERIS model (MOdelling Nutrient Emissions in RIver Systems) was developed and applied for the evaluation of nutrients emissions (nitrogen and phosphorous) in many basins/districts from Europe, including in the Danube basin/district. Apart from point sources (from municipal waste water treatment plants and direct industrial discharge), MONERIS model takes into consideration the following pathways responsible for the diffuse pollution: atmospheric deposition, groundwater, tile drainage, urban areas e.g. (paved urban areas, precipitation run-off), soil erosion and overland flow (e.g. surface runoff).

The groundwater run-off represents the main pathway of diffuse emission for nitrogen and the run-off from impermeable sources has the biggest contribution to the diffuse emission of phosphorous. Furthermore, MONERIS model quantifies the input of various sources of pollution to the total emission of nutrients. For example, the categories responsible for diffuse sources of pollution are municipalities, agriculture, others (i.e. atmospheric deposition of nitrogen oxides) as well as the natural background. It should be stressed that MONERIS model takes into account all type of sources of pollution not only the significant ones.

For the Romanian part of the Danube River Basin, the nitrogen diffuse emission is caused by agricultural activities and human agglomerations and the most part of total diffuse emission of phosphorus is caused by human agglomerations. It is mentioned that the diffuse emission of N and P is much lower compared to other countries where agriculture is more intensive.

One of the important piece of EU legislation is the Council Directive 91/676/EEC (Nitrates Directive) concerning the protection of waters against pollution caused by nitrates from agricultural sources which was fully transposed in the national legislation through Government Decision nr. 964/2000 on the approval of the Action Plan for the water protection against pollution with nitrates from agriculture sources.

The main requirements of the Action Plan are:

- Identifying waters affected by nitrate pollution or susceptible to pollution and establish the appropriate monitoring programs;

- Developing a code of good agricultural practices and programs for training and information of the farmers in order to promote this code;

- Development, implementation and put in practice of the action programs.

In order to identify the water affected or likely to be affected by nitrates from agricultural sources, the following criteria are used:

- Exceeding of the limits set by legislation for surface water used for drinking purposes;

- Exceeding of the limits set by legislation for groundwater used for drinking water abstraction;

- Freshwater sources (natural lakes, reservoirs, canals), coastal and marine waters are eutrophic or may become eutrophic in the near future.

Based on analytical data (average, minimum and maximum values) obtained in each monitoring section, the surface water and groundwater quality assessment has been done. Very important is also the trend assessment of the nitrates concentrations both in surface and groundwater. For this purpose, the monitoring data considered are physico-chemical parameters: nitrates, nitrites, total nitrogen, phosphates and total phosphorous, dissolved oxygen and organic substances (measured through BOD5), chlorophyll "a" (in those stations were the risk of eutrophication exists). To identify the eutrophication phenomena, it is necessary to use the monitoring data sampled especially in summer period.

In this context, it is necessary to implement measures for addressing the nutrients pollution according to the UWWT Directive and Nitrates Directive requirements and also, measures required by other directives in water quality fields and if necessary, supplementary measures in order to reach the WFD requirements.

SERBIA

National activities for controlling and managing nitrogen and phosphorus emissions in Republic of Serbia

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1. Conditions

Institutional context and legislation

The Republic of Serbia passed new Law on Water in 2010. The Law was ammended in 2012 and it represents transposition of the articles from the EU Water Framework Directive and partially EU Flood Directive into national legislation.

Integrated management of the water resources is distributed throughout Ministries, authority of the autonomous province, the bodies of local authorities, public water management companies. Ministry of Agriculture and Environmental Protection (http://www.mpzzs.gov.rs) respectivly Water Directorate (http://www.rdvode.gov.rs/index.php),Agency for the Environmental Protection (http://www.sepa.gov.rs), Ministry of Health, Ministry of Regional Development and Local Government, Government of Autonomous province of Vojvodina and PWM Companies "Srbija Vode", "Vode Vojvodine" and "Beograd Vode"are competent authorities in overall water management in Serbia.

Water Directorate performs following tasks related to: water management policy; multipurpose use of water; water, except for water distribution; protection of water; implementation of measures for the protection of water resources and planned rationalization of water consumption; monitoring and maintanace of the water regime; international cooperation in water management; inspection in the field of water management such as International Commission for the Protection of the Danube River - ICPDR and International Sava River Basin Commission - ISRBC as internationally established bodies for River Basin Management of the Danube and Sava River respetivelly.

On the other hand Agency for the Environmental Protection among other tasks perfoms and implements the programs for monitoring and control of the water quality in surface and groundwater bodie, cooperation with international bodies EIONET and EEA.

Monitoring of the surface and groundwater bodies from the flow and temperature aspect is under the juristiciton of the Republic Hydrometeorological Service of Serbia (http://www.hidmet.gov.rs).

Strategies and programme of measures

In 2012 Republic of Serbia issued "S*trategy for the approximation in water sector*". This document is in tight corellation with the "*The National Strategy for the approximation in sector of environment*", issued in 2007.

The Agency for the Environmental Protection perfoms and implements the programs for monitoring and control of the water quality in surface and groundwater bodies.

The Agency presents reports of measurements on:

1. *Daily* - data can be obtained via following link:
   http://80.93.233.118:8080/apex/f?p=406:4:0:::::

2. *Weekly* - available as a document report via following link:

   http://www.sepa.gov.rs/index.php?menu=305&id=8015&akcija=ShowAll

3. *Yearly basis* - On yearly basis the Agency for the Environmental Protection issues "*Report on the status of the environment in the Republic of Serbia*" (http://www.sepa.gov.rs/index.php?menu=305&id=30000&akcija=showAll) the document for the year 2012 was issued in December 2013.

Current conditions of nutrients pressures and impacts and On-going scientific assessments

For the section of the **Danube river** in Serbia the current condition of nutrient pressures and impacts is carried out via ICPDR (http://www.icpdr.org/main/activities-projects/river-basin-management) and it is elaborated in three documents:

1. Danube Basin Analysis - issued in 2004

2. Danube River Basin management plan - issued in 2011

3. ICPDR TNMN - operational

4. Joint Danube Survey 1,2 and 3 - latest carried out in 2013 (http://www.danubesurvey.org/)

For the section of the **Tisza river** in Serbia the acitivities are carried out via ICPDR:

1. Tisza River Basin Analysis Report - 2007

2. Integrated Tisza River Basin Management Plan - 2011

For the section of the **Sava river** in Serbia activities are carried out via ISRBC:

1. Sava River Basin Analysis Report - 2009

2. Sava River Basin Management Plan - final draft version.

For the national surface water bodies the scientific assessment and estimation of current condition was carried out for the **Danube, Sava, Kolubara** and **Morava river** via "*Report on the status of the environment in the Republic of Serbia*".

As written in report based on the monthly value annually for each measurement point calculated median arranged a series of data from measuring points and obtained an indicator of quality parameters for BOD5 (mg / l), ammonium ion (NH 4-N mg / L), nitrate (NO 3-N, mg / l) and Orthophosphate (PO 4-P mg / l). BOD5 - 57 measurement locations; NH4-N, NO3-N and PO4-P- 75 measured locations.

Results of analysis of long-term trends nutrient concentrations data period from 2001 to 2012 shows that the contribution of parameter is the most abundant nutrient ammonium ion, as a percentage of its 58% satisfies the range of the lowest compared to orthophosphates (74%) and nitrate (99%) (*Report on the status of the environment in the Republic of Serbia, 2012)*. The surface water bodies in Serbia have good or above good ecological status levels.

Scenarios of impact of land use and climate changes

Projected high temperature, frequent drought episodes and increased frequency of wildfires, the decrease in summer precipitation and frequent occurrence of heat waves will negatively affect the productivity of crops. In the worst case scenario of climate change (A2), in Serbia can be expected yield reductions of up to 30%.

Water Sector scenarions outputs reduction of the availability of fresh water; increase the frequency and intensity of flash floods and landslides; reduction of hydropower potential in certain areas; reduce the number of days with snow and snow cover, with negative effects on winter tourism; reduction in water quality due to the increased frequency of droughts and floods.

Agriculture and Forestry Sector: crop yield reduction due to drought učestanih accompanied by high temperatures; increase in livestock diseases; land degradation due to water erosion, salinization, etc.. Degradation of forests due to frequent fires, shifting bioclimatic zones, synergetic effect of environmental pollution and climate change.

Various projects dealing with issue of climate change and impact to the water resources and land use have been realised and are still active:

Climate Change and Impacts on Water Supply - "CC-WaterS" - SEE Project from 01.05.2009 until 30.04.2012. CC-WaterS will identify and evaluate climate change impacts on availability and safety of public drinking water supply and propose adaptation measures, considering their socio-economic consequences (http://www.ccwaters.eu/index.php?option=com_content&view=article&id=101&Itemid=123&56b00064c3e6beb26da3b96d1578b92a=82ae43a98d9aa6fc54bf99eb308abd1b).

2. Solutions

Implementation of the policies and in the achievement of targets

Major obstacles and bottlenecks:

1. Continues monitoring of the water quality status on all surface and groundwater bodies.

2. Lack of financial resources for monitoring and process of implementation of the articles. According to the results presented in "*Strategy for the approximation in water sector" as presented in figure bellow* the total cost of investment required is about 5.5 billion euros for three directives. It amount represents large financial resource.

The objectives, compliance and implementation requirements for:

1. Directive on drinking water :

Achieve the objective for the establishment of municipal water supply, which are determined;

Public water supply - it is unlikely that this fully achieved until the late 2020s.

2. Directive on the quality of drinking water :

Settlements that are connected to the supply system - it might, depending on the priority given to specific investments, to achieve the comliance before the 2020;

Posibility to consider a request for a short transition period for those supply areas in which problems related to water quality may persist and after 2018.

3. Directive on Urban Waste Water Treatment:

Unlikely that it will achieve full compliance with the requirements for agglomerations before 2030-2033;

4. Nitrates Directive:

Realistic to assume that full compliance will be achieve in the mid 2020s;

5. Water Framework Directive:

Transition period for the Water Framework Directive may be given to the achievement of environmental goals based on the Implementation Completion program UWWTD. However, given the provisions of Article 4, it is recommended that Serbia does not require a transition period, but to agree to the sharing of information obtained temporary derogation from Article 4.4, since it will not be able to fully meet his demands, given the difficulties encountered in the implementation UWWTD.

SERBIA

Modeling and assessment of diffuse water pollution load in the Republic of Serbia – case study for Kolubara river basin

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Introduction

This paper shows an overview of the latest research related to diffuse pollution originating from runoff from various land use, agricultural surfaces, urban and rural areas and forest resources. In the Republic of Serbia there is a legal obligation that the water management plans should contain an assessment of pollution from diffuse sources. This is why the present work is intended for various interested users: ranging from those who have heard for the first time about diffuse pollution, down to experts in water and soil protection who may find it useful in solving different problems and the local self-government and state officers performing various administration duties in the area of environmental protection.

The data relevant for assess a diffuse pollution load in the Pilot area were obtained in the framework of the project "An improved system for assessment of water pollution from diffuse sources in Serbia". The objectives of the project were to establish and adopt diffuse pollution management methodology based on the experience of EU, to implement the Water Framework Directive and Nitrates Directive and to draft a proposal related to harmonization of national regulations. The project was also intended for coordination of the relevant authorities as regards management of diffuse pollution and improvement of technical skills in the area of diffuse pollution management.

The results of the Project are, for Serbian conditions, new methods, models and assessment tools for management of diffuse water pollution. Guidelines have been developed for monitoring and assessment of pollution in water bodies and river catchments, including load assessments from different sources and in rivers. Further, the methodology has been applied to the Kolubara catchment in NW Serbia. The assessment of diffuse pollution obtained by using the *FyrisNP model* for the Kolubara Catchment has shown that this model could be used in the process of adoption and application of the Nitrates Directive (*Council Directive 91/676/EEC*). The application of this model could be an integral part of the *Water Management Plan* (Article 33 par. 2, *Law on Water*, Off. Gazette RS 30/10). The assessment of diffuse pollution of soil and water from agricultural areas is a main objective for period 2010-2019. according to National Environmental Protection Programme („Off. Gazette RS 12/10).

Material and methods of work - Input data and load modelling using FyrisNP

In the process of improving the system for evaluation of diffuse water pollution in the Republic of Serbia, in the project for Kolubara catchment FyrisNP model was applied. Model was developed at the Uppsala University, Sweden *(Department of Aquatic Sceince and Assessment at Swedish University of Agricultural Sciences, Uppsala*). The dynamic FyrisNP model calculates source apportioned gross and net transport of nitrogen and phosphorus in rivers and lakes. The main scope of the model is to assess the effects of different nutrient reduction measures on the catchment scale. The time step for the model is in the majority of applications one month and the spatial resolution is on the sub-catchment level. Retention, i.e. losses of nutrients in rivers and lakes through sedimentation, up-take by plants and denitrification, is calculated as a function of water temperature, nutrients concentrations, water flow, lake surface area and stream surface area. The model is calibrated against time series of measured nitrogen or phosphorus concentrations by adjusting two parameters. Data used for calibrating and running the model can be divided into time dependent data, e.g. time series on observed nitrogen and phosphorus concentration, water temperature, runoff and point source discharges, and time independent data, e.g. land-use information, lake area and stream length and width.

In order to perform simulations with the FyrisNP model, an Excel-file containing all input data is required. The Excel data file contains between eight and ten different work-sheets depending on what features are used. Input data for the FyrisNP model includes spatial and alphanumeric data grouped in eight main groups: a) delineation of sub-catchments, b) land use, c) EMEP/MSC-W modelled depositions of nitrogen, d) leaching concentrations of nitrogen and phosphorus in runoff from arable land and pasture and other types of land use, e) lakes, f) minor point sources – scattered rural households, g) minor point sources- manure depots and h) major point sources– urban and industrial sewage systems. Besides these, other data will be included in the model: results of surface water quality monitoring, specific runoff from sub-catchments, specific concentrations of nitrogen and phosphorus discharged from non-agricultural surfaces, etc. All this data can be divided into two large groups, time-dependent and time-independent data.

Results and discussion – Output load assessment and apportionment charts

For the Kolubara catchment data from 52 sub-catchments have been added. The data includes time series of average monthly concentrations of total Nitrogen and Phosphorus for 5-year period (2006-2010), with a time interval of one month, or 60 intervals in total (Veljkovic et all, 2013).

The application window *Results* allows for activating the function *Plot, Copy, Write file* for export of output (calculated) data from the model and diagram presentation of load assessment and apportionment in the required format (txt, jpg, png, gif…). The Figure 1. shows output results, obtained after making the query *Internal load,* i.e. gross and net mass flows of total Nitrogen, broken down by sub-catchments. The magnitude of retention of total Nitrogen in each sub-catchment can be observed from the difference between gross and net mass flow.

The Figure 2. illustrates the impacts of all pollutants on the most downstream point in the Kolubara catchment (at the confluence of the Kolubara and the Sava river).

Around 50% pollution of total Phosphorus originates from major point sources, while only 7.1% is due to forests as diffuse pollution source.

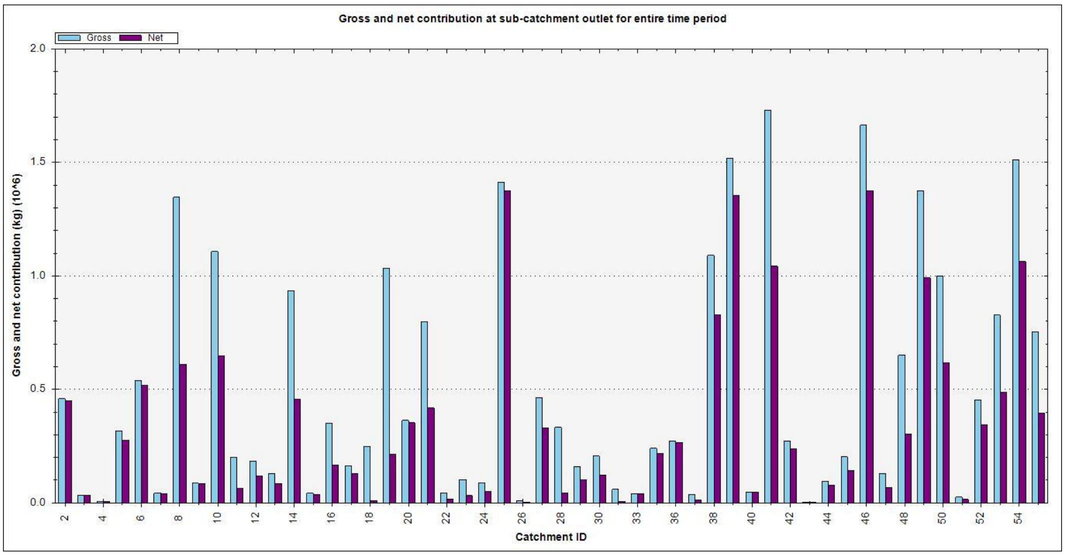

Figure 1. Gross and net mass flow of total Nitrogen at the outlet of sub-catchments

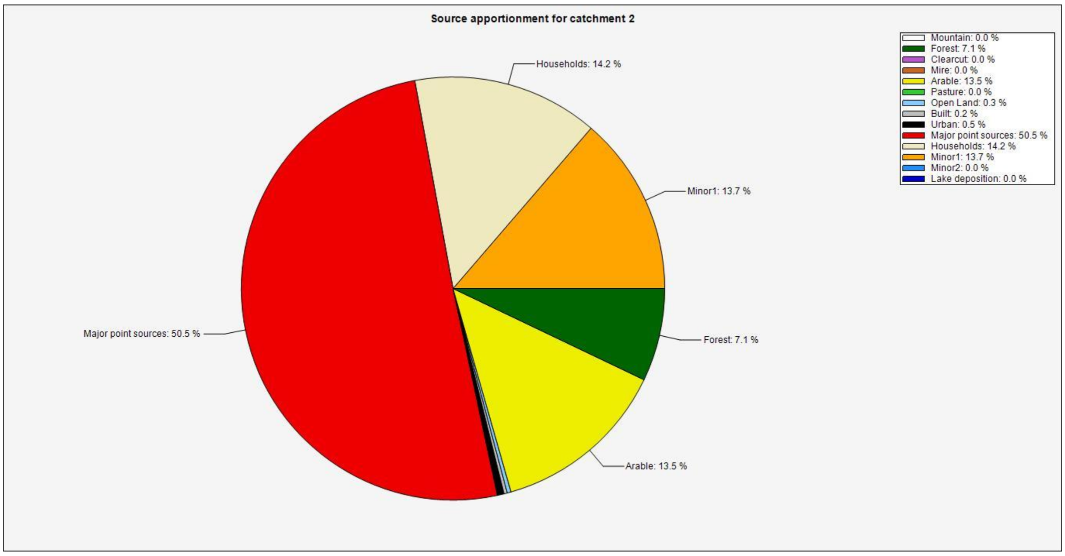

Figure 2. Relative values of mass flow of total Phosphorus from individual sources at the outlet of the Kolubara catchment

Output results obtained after making the query *Catchment control* are shown in a tree diagram, with defined inter-relations and upstream/downstream arrangement of sub-catchments. The intensity of load of total Phosphorus has been visualized in different colors for each sub-catchment. (Figure 3) The Figure shows gross load of total Phosphorus (kg) from the sum of all pollution sources, broken down by sub-catchments and in relation from the most downstream point of the Kolubara catchment. Most gross load of total Phosphorus originates from the sub-catchment -39 where the discharge point of the Valjevo city system is located (Veljkovic et all, 2013).

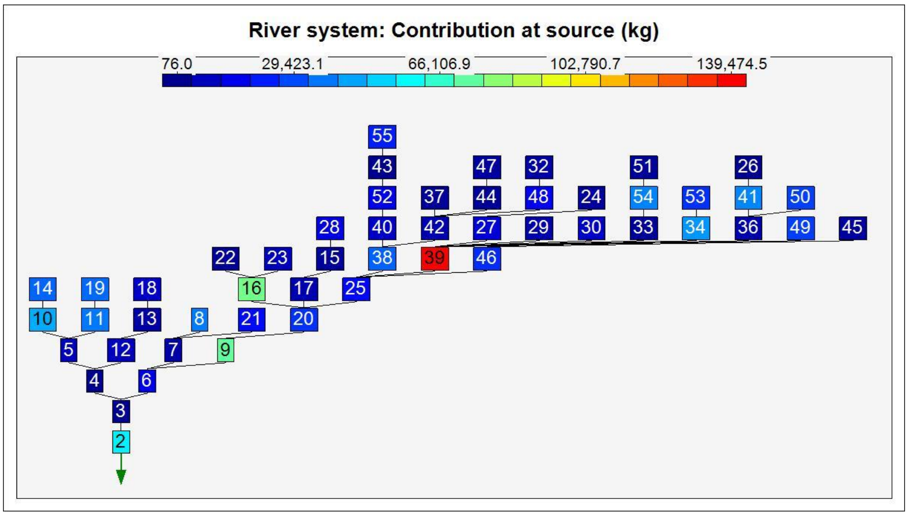

Figure 3. Contribution at sources

Conclusions

The reliability of the results of nutrient load obtained by using the *FyrisNP model* for the Kolubara Catchment has shown that this model should be used in the process of adoption and application of the Nitrates Directive (*Council Directive 91/676/EEC*) in the Republic of Serbia. Spatial distribution of the crops, broken down by sub-catchments, may be obtained by using satellite and aero-photo images, which increases the precision of the input data.

In order to make a more precise modelling as regards data related to the use of mineral and organic fertilizers, broken down by type and quantity, statistical accounting is required about their spatial and time dynamics of use.

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SLOVENIA

Slovenian approaches for controlling and managing nitrogen and phosphorus emissions from human land-based activities

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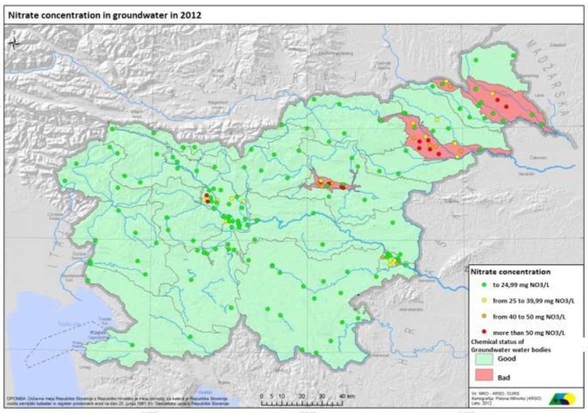
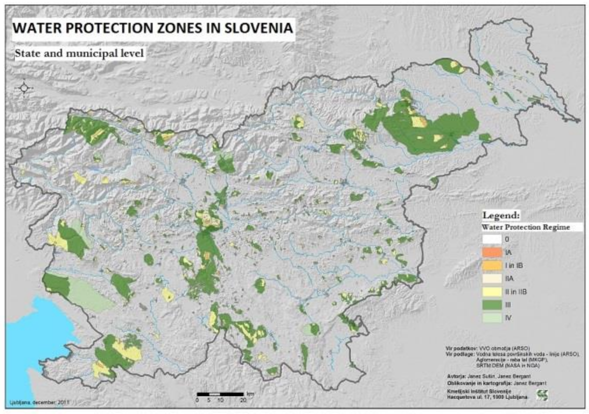
The current nutrients pollution of surface waters with nitrogen is a result of leaching from agricultural lands, and the contributions of municipal and industrial wastewaters. For pollution with phosphorus are the most common cause's wastewater from industry and sewage from households. Statistically significant trends in nitrate and orthophosphate levels in a given period (1998-2012) were not observed. The nitrate values are slightly above the background, which is stated for the majority of European rivers (the EEA data limit is 1 mg N/l). Orthophosphate levels exceed background levels, reported for the majority of European rivers (10 mg P/l). A high biochemical oxygen demand usually originates in organic pollution caused by discharges of municipal and industrial wastewater and leaching from agricultural land. After 2005 the values dropped considerably. Reduction of biochemical oxygen demand is a result of improved waste water treatment and abandonment of industry, which heavily pollute rivers with waste water.

Groundwater is in Slovenia the most important source of drinking water, which supplies more than 95% of the population. In flat areas of river valleys dominate aquifers with intergranular porosity (alluvial aquifers). Nutrients loads are here because of intensive human activities such as agriculture, industry, transport, dense population and landfills, the largest. Agriculture is the most developed in the north-eastern and central part of Slovenia and in the river valleys plains (Drava, Mura, Savinja, Sava), which are dominated by alluvial aquifers. This is also reflected in excessive levels of nitrates in groundwater, most of which are higher than the natural background at many monitoring stations also higher than the standard of 50 mg NO_3/l. From 2007 onwards, the average annual nitrate levels in the most polluted water bodies do not exceed quality standard and are falling. In the Alpine and Karts regions are dominated by karst and fissure porosity aquifers. They are very vulnerable, but in Slovenia are mostly naturally protected because they lie in the mountainous, less populated areas that are overgrown with forests. In most of these water bodies are the average annual concentration of nitrate below 10 mg NO_3/l and it never exceeded 25 mg NO_3/l.

For the most vulnerable water bodies are characteristic very shallow soil (30 to 50 cm), where the path of nitrate to ground water is significantly shorter than in the case of deeper soils (>50 cm), where nitrate concentrations in groundwater are not exceeded. An additional cause of poor water quality is an extensive agricultural production. In the area of the Krško and Drava basin water bodies fields represent about 47% of the water body area and in the area of the Mura basin 57%. At others water bodies is the share of arable land significantly lower. The quality of water is also influenced by annual rainfall, which affects the level of nitrate leached into groundwater and on the levels of groundwater. In addition to agriculture have an important role to play "non-agricultural factors", particularly unregulated waste waters (septic tanks).

Among all water bodies in Slovenia have water reservoirs the highest measured loads and concentrations of phosphorous especially in the central and north-eastern Slovenia, as a result of their position in areas with intensive agricultural land use and still not completely regulated municipal infrastructure. High average phosphorus concentrations of 100 µg/L were measured in Perniško, Ledavsko and Gajševsko lakes. A large proportion of nutrient loads and phosphorus in all reservoirs originates in intensive fishing activities from carp-catching to aquaculture. Downward trends of phosphorus were still not observed, occasional fluctuations in the concentration of phosphorus between the years in the reservoirs are only the result of specific hydrological and meteorological conditions during sampling.





The on-going scientific assessments are from the point of monitoring methods moderate and from the point of the modelling methods weak. On all major water bodies in the country runs a regular national quality monitoring, which is performed by Slovenian Environmental Agency and includes sampling of water at least 4 times a year. Monitoring programs are prepared on an annual basis in accordance with current legislation. Since 2003, the monitoring includes all lakes with a surface area greater than 0.5 km^2. The monitoring of river water quality includes about 90 measuring points per year. The monitoring of groundwater includes 185 measurement points distributed throughout all 21 bodies of water. Groundwater is sampled at sampling points 1 to 2 times a year.

River basin or catchment modelling of nutrient losses is still under the development phase. Model that was mostly used (University of Ljubljana) at proper scale (yearly, monthly and daily) was SWAT (water balance, land use change and management, agri-environmental measures, climate changes) and in one example further combination with ModFlow (Geological Survey of Slovenia) was made to investigate nutrient transport and transformations in groundwater. Combination of GROWA-DENZU-WEKU-SI models is still under development by FZ JULICH (Germany) for Slovenian Environmental Agency and will be operating on yearly scale for the whole country until the end of 2014 and on monthly scale until the end of 2015.

There were two researches investigating impacts of land use and one investigation impact of climate changes in Slovenia done by Biotechnical Faculty of University of Ljubljana. Impact of land use (Historical land use data), land management (rotational schemes) and agri-environmental management (Rural development programme) on nitrogen, phosphorus and sediments were investigated in two flysh catchments and nitrogen leaching past the bottom of soil profile in alluvial plain. Impacts of climate changes (RCM) on N and P transport were also investigated in flysh catchments.

The institutional context and legislation is mostly connected with introducing and enforcement of EU directives in national legislation. In this context Slovenia applied action programme from Nitrate directive (91/676/EEC) to the whole territory. It concerns all agricultural holdings that carry out fertilisation and agricultural holdings that produce livestock manure. Main restrictions are limit of use to 170 kg N/h per year for livestock manure, periods when the land application of certain types of fertilisers is prohibited, the rules for fertilisation on water-saturated, flooded, frozen or snow-covered ground, the rules for fertilisation in the vicinity of watercourses, the smallest permitted capacities of facilities for the storage of livestock manure and cross-compliance for agricultural subsidy payments. Water management plan and river basin management plans successfulness (Water Framework Directive, 2000/60/ES,) aiming all water would achieve good chemical and ecological status until 2015, are highly dependent by daughter directives successfulness. This is especial the case for the nitrate and phosphorus (Nitrate Directive, Groundwater Directive, Fish Directive, Urban wastewater Directive). However, financial support for reducing nitrogen and phosphorus from land based activities manly originate in Common Agricultural Policy (Rural Development Programme, Cross-compliance)

Water protection zones are protected by municipal and governmental regulations. They are defined with the aim of protection water bodies that are used or intended for public drinking water from pollution, which could affect the wholesomeness of the water or its quantity. Almost one fifth of the territory of Slovenia (345,000 ha), is water protection area, of which more than 7,000 hectares in under strictest protection regime. Fields represent 36% of the surface water protection areas and their scope is significantly reduced, mainly at the expense of grassland.

In order to reduce pollution of groundwater with nitrates loads are since 1996 enforced restrictions on stocking rates per ha of agricultural land and environmentally friendly methods of fertilization. Important role is also played by agri-environmental measures of the Rural Development Programme under CAP. Within the framework of the Rural Development Programme launched in 2004 the adaptation measures to Nitrate Directive in agriculture were set. Under these measures all farmers were obligated and financially awarded for building new water tight storage facilities for animal manure on farms, which will certainly contribute to a better state of groundwater. The results of all these measures can only be expected in the coming years.

According to data from 2013 is in Slovenia the coverage ratio of population connected to the communal infrastructure of waste water discharges 55 %. This means that we are among the countries where the share of population connected to public sewage treatment plants is low and nearly half of the population in Slovenia is still using septic tanks. This certainly impact the environment and blurs effects of adapted land based activities.

Analysis of the results showed that strategies taken in to action as a product of enforcing European legislation in 2004 (Water Framework Directive, Nitrate Directive, Groundwater Directive, Urban Wastewater Directive, Fish Directive) resulted in relative better condition of water bodies. However, certain water bodies quality is still bad despite different measures introduced.

European commission point out to the Slovenian government major obstacles and bottlenecks in the implementation of the policies and in the achievement of targets. They point at absence of real analysis of cost effectiveness - Individual cost-effectiveness studies should be carried out on certain practices. They point out that analyses of future development of water quality are missing and that there is a lack of methodologies and lack of appropriate modelling tools.

TURKEY

Determination and management of sensitive areas on the basis of watershed in Turkey

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ABSTRACT

Eutrophication is a water quality problem as a biological event that formed under the influence of many factors. Ammonia, nitrate, nitrite, phosphate, and other inorganic substances which are the main reasons of eutrophication and formed due to microbial decomposition of organic waste not only affect benthic organisms, but also lead to a change in habitat and result in the formation of sensitive areas.

With the project "Determination of Sensitive Areas and Water Quality Objectives On The Basis of Watershed in Turkey" sensitive water areas in terms of water pollution, nitrate vulnerable water areas, and nitrate vulnerable zones in the surface waters, water quality objectives and measures to be taken to improve water quality will be determined in twenty five river basin in Turkey.

In this context, "Watershed-Based Integrated Water Management Approach" that is implemented by the Member States of the European Union under the Water Framework Directive has been adopted in Turkey, and also determination and management of sensitive areas will be considered in this approach.

Urban wastewaters, industrial wastewaters and runoff waters from agricultural areas change ecological status of the current system and lead to degradation of water quality and increasing production of algae due to the nutrients by affecting directly and indirectly physical, chemical and biological processes of aquatic environment. Eutrophication occurs over time as a result of death and deterioration of algeas with decrease in the amount of oxygen in the water.

Water resources should be considered with integrated water management approach which include physical, social, economic and environmental factors by meeting the requirements of current and future. This issue have been raised in recent years and started to be implemented in other countries. The basis of integrated management of water is to accept water both natural resource and as a commodity which may change depending on the purpose of use as well as the quantity and quality.In Europe, water legislation has been implementing under Water Framework Directive (WFD) by adopting the integrated water management. The Water Framework Directive reveals a more coherent and integrated approach for the management of eutrophication in water by fully taking into account the requirements of the Nitrates Directive and Urban Waste Water Treatment Directive.

In the context of harmonization of the WFD to national legislation in Turkey, studies are ongoing related to determination and management of sensitive areas. In this project, sensitive water areas in terms of water pollution, nitrate vulnerable water areas, and nitrate vulnerable zones in the surface waters, water quality objectives and measures to be taken to improve

water quality will be determined in twenty five basin in Turkey. The project started in September of 2012 and will be completed by the end of 2015.

In the project, water bodies were determined on surface waters in the twenty five basins.1814 river water bodies and 656 lake water bodies were determined in the Project. Pressures and pollution loads that resulted from urban, industrial and agricultural activities were determined on the basis of the basin in water bodies. Then, water pollution will be determined by monitoring activities. After all, sensitive water areas will be determined for inland waters by evaluating the data which are obtained as a result of pollution loads and monitoring in surface waters (including coastal and transitional waters). On the other hand, water quality objectives regarding sensitive water areas and measures that are necessary to improve water quality including wastewater treatment systems will be determined. And also specific water quality models developed for Turkey will be used in this project. Finally, measures determined in accordance with the water quality objectives, will be reviewed.

TURKEY

Nitrate directive harmonization and adaptation studies in Turkey

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Rapid population growth increases the food demand and need of food security as well as clean water demand and water security in Turkey. Turkey has 76 667 864 population by the last data served by Turkish Statistical Institute. In order to feed the population Turkey is cultivating 24, 5 Mha land which is the 31,5 % of its surface area. One of third of this cultivated areas are irrigated. Therefore 72% of available water is used by agriculture. The common belief of having more yields by using more fertilizer and irrigation of farmers is one of major problem that institutions are dealing with. In order to raise the awareness of farmers on this illegitimate belief coming from the past, the agricultural governmental broadcasting institutions regularly release educational broadcasts with scientific supports. In addition to that Turkey had started to adapt the national policies to the EU Nitrate Directive by 2005. In this context, "Reducing Nitrate Pollution Resulted from Agricultural Resources and Implementation ((91/676/EC) of Nitrate Directive ((PPA 04/TR/7/6) in Turkey" project was initiated with multi-institutional cooperation by Ministry of Food Agriculture and Livestock. The chronological plan of the projects is given in Figure 1.

WATER QUALITY MONITORING STUDIES	2005-2021
STUDIES FOR DETERMINATION OF NITRATE VULNERABLE ZONES	2011-2015
GOOD AGRICULTURAL PRACTICES CODE PREPARATION STUDIES	2011-2016
ACTION PLANS AND NEGOTIATION STUDIES	2011-2017
CAPACITY DEVELOPMENT AND AWARENESS STUDIES	2012-2017

Figure 1. Harmonisation of National Policies with EU Nitrate Directive

A plot implementation project, called as "Anatolia Watershed Rehabilitation Project", under adaptation to Nitrate directives in Turkey, was performed in some provinces of those surface waters discharge into the Black Sea. In pursuit of this project, water quality monitoring network was established in 2005 with 2631 monitoring points (Figure 2). 20 mobile laboratories were equipped for the purpose of in-situ nitrate analysis under control of central reference laboratory. Furthermore, web bases Nitrate Information System (NIBIS) has been established with variable restricted access rights to provide online excess and edit opportunities for updating the monitoring network data.

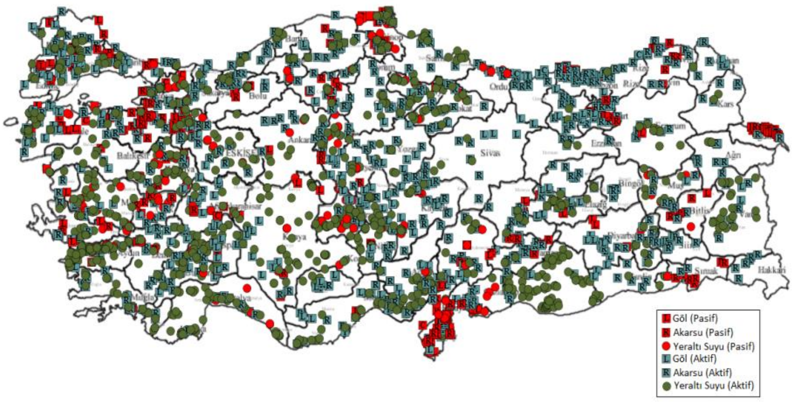


Figure 2. Surface (1337-monthly) and groundwater (1257- quarterly) nitrate monitoring network

The nitrate in water bodies are evaluated and graphed using online network data. Two of sample is illustrated in Figure 3.

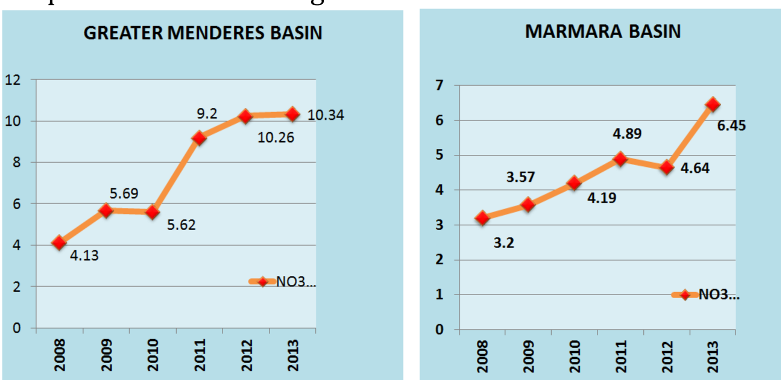
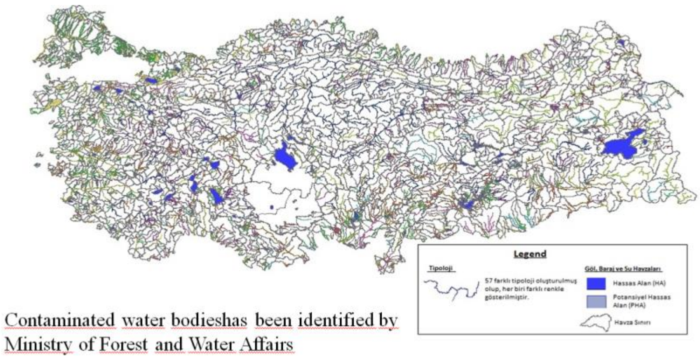


Figure 3: Nitrate changes in G. Menderes and Marmara basin between 2008 and 2013.

Figure 4 is illustrating the nitrate sensitive river networks.



Water Mass Count		Sensitive Water Mass			Potential Sensitive Water Mass		
Lake-Dam	Stream	Lake	Dam	Stream	Lake	Dam	Stream
656	1.814	356		363	59		509

Figure 4 Sensitive surface water bodies

Figure 5 illustrates the potential NVZs in Turkey by 2012.

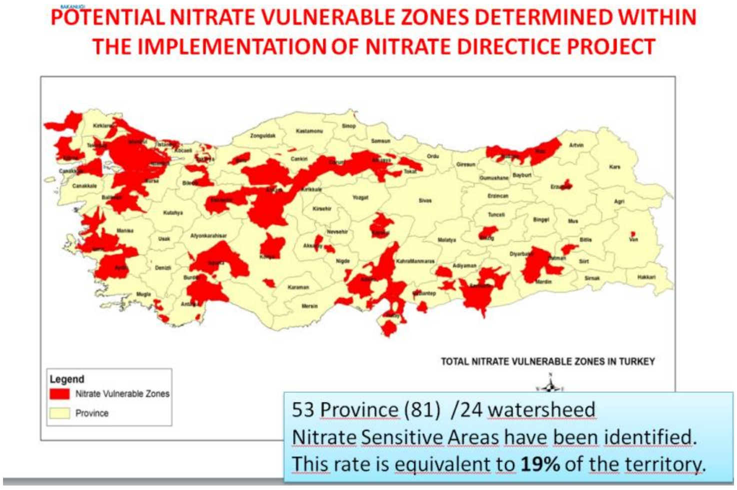
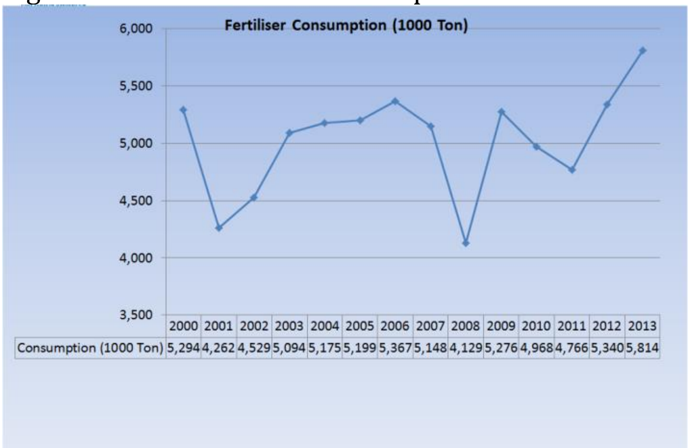


Figure 5. Potential NVZs on Turkey

Figure 6 shows fertilizer consumption and trends in livestock number in Turkey.



Year	Cattle number	Sheep-Goat number
2003	9.901.458	32.203.214
2004	10.173.246	31.811.092
2005	10.631.405	31.821.789
2006	10.971.880	32.260.206
2007	11.121.458	31.748.651
2008	10.946.239	29.568.152
2009	10.811.165	26.877.793
2010	11.454.526	29.382.924
2011	12.483.969	32.309.518
2012	14.022.347	35.782.519
2013	14.532.848	38.509.795

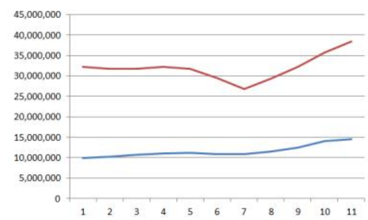


Figure 6. Fertilizer consumption and trends in livestock number in Turkey

Our national policy is to prevent nitrate pollution in surface and groundwaters using good agricultural practices code while increasing efficiency in agricultural production. The actions mentioned briefly above are the implementation parts of our policy and still we are working on improving the policies to be more efficient.

UKRAINE

Nitrogen and phosphorus monitoring and modeling in Ukraine

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The main new feature of EU Water Framework Directive policy, which Ukraine has to approximate in ten years after signing an Association Agreement in 2014, is that WFD is the obligation of results – reaching good status for all waters, while Ukrainian policy is still only the obligation of means. The National Environmental Policy (2010) in the water sector "… aims to stabilize and improve the state of the environment in Ukraine … by rehabilitating the existing and constructing new municipal treatment facilities in order to provide a 15 per cent reduction in water contamination by pollutants (in the first place, by organic substances, nitrogen and phosphorus compounds) by 2020". No targets for the state of waters are established.

For that reason the monitoring cycle in Ukraine was designed to provide the information needed to answer specific questions in such type of decision-making – state of waters is assessed by Water Pollution index - WPIk = 1/N Σi=1...N Cik / C0i , where Cik is the concentration and C0i is Maximum Allowable Concentration (MAC) of ith pollutant in the monitoring point k, or rather by Integrated WPI - 1/MΣk=1...M WPIk . This goes back to the "zero-risk" Soviet Assessment style where WPI has no direct legal or other suchlike implications for the water management. It is merely a way of trying to make the results of monitoring more easily accessible and understandable.

In case of impact assessment of the biogenic pollution in Ukraine this leads, in particular, to such paradox when, for example, in most of the Dnipro River reservoirs as well as the areas of the Black and Azov Sea and Kerch Strait the content of phosphorus and nitrogen is below MAC, but the ratio of organic and mineral components indicates significant anthropogenic impact on water ecosystem and, respectively – eutrophication of waters.

In the situation when setting of the state of water targets is absent in Ukrainian Environmental Water Policy, use of modeling makes little sense for the decision makers as they neither need to achieve acceptance of society for environmental policies and their successful implementation nor to estimate the expected and achieved effect of a measure or run scenario simulations for optimal measures allocation to improve water quality in a catchment. Only scenario analyses ask for a predictive model, which should be process-based and thus, normally are linked to a hydrological model for description of the transporting medium (i.e. water flow).

At the same time, use of water modeling has long and successful history in Ukraine. Mainly because of Chornobyl disaster when it became necessary to develop the strategy of prevention of radioactive contamination of water bodies in Ukraine. The overview of this development and use of water modeling one can find in our special e-lecture made public on youtube.com: https://www.youtube.com/watch?v=bb2MdodRYsU&list=PLeJ1Ix5jTF2gnnTBGmMd5PEFjaw-9dj_F&index=5

The model system used for modelling of chemical pollution in Ukraine includes:

- One-dimensional models (developed in house and by other organizations) used, for example, for analysing the effect of water releases from Kakhovka Reservoir on the pollution propagation from the mining area in Krivoy Rog through Ingulets to the Dnipro River and further down;
- The two-dimensional, transversely averaged hydrodynamics and water quality model (CE-QUAL-W2) used, for example, to analyse the effect of reservoir operation on the salt-water intrusion from the Black Sea and to evaluate the necessary water transport for the maintaining of appropriate water quality of the lower Dnipro. The following parameters are calculated: elevation of the free surface, longitudinal horizontal velocity, vertical velocity, the temperature, salinity, suspended solids and water quality parameters (dissolved oxygen, algae, phosphates, ammonia nitrogen, nitrate nitrogen, mineral carbon, pH, carbon dioxide and BOD);
- The three-dimensional (THREETOX/WASP) model, which includes a hydrodynamic module for calculating in-stream temperature and salinity fields, module for calculating processes of the estuary eutrophication as well as modules for the calculation of the transport of suspended sediments and toxic substances. The nutrient cycling or eutrophication submodel is functionally equivalent to the U. S. Environmental Protection Agency's WASP5 model. The submodel simulates the transport and transformation reactions of up to eight state variables that can be considered as four interacting systems: phytoplankton kinetics, the phosphorus cycle, the nitrogen cycle, and the dissolved oxygen balance.

Model simulation of chemical pollution in lower Dnieper, Dnipro-Buh Estuary and the Black Sea provided the opportunity for the following conclusions from the models used:

- The 1D simulation of the Ingulets – Lower Dnipro system shows that it could be recommended to decrease the discharge through Kakhovka Hydro Power Plant to 500 m3s-1 during the period when the waste water peak arrives at the junction of Ingulets and Dnipro. In this way it is possible to accelerate the propagation of the pollutants in lower Ingulets;
- The 3D simulation of the Kakhovka reservoir water quality shows that the influence of the water discharge from Zaporizhska Nuclear Power Plant on the hydro chemical parameters is not the dominating factor. More significant is the rate of the nutrient sources from the cities around the reservoir and the nutrient flux into the reservoir from the up-stream reservoirs via the Dneprovsky HPP dam upstream.
- The main conclusion that could be made on the basis of the simulation study is that a reduction of the Kakhovka discharge below 400 m3s-1 leads to a reduction of the dissolved oxygen concentration at the bottom layers of the main river channel. These results show that discharges in the range of 400-300 m3s-1 could not damage the ecosystem except when the duration is shorter than one week.

3. Breakout sessions and discussions

Two breakout sessions were organized during the Workshop. The first one focused on addressing and developing a common understanding of integrated nutrient management by debating the following questions:

- What should be the main goals of developing Integrated Nutrient Management?
- Which sectors and stakeholders should be included?
- How to integrate objectives of EU and non-EU policies?
- What are the appropriate spatial and temporal scales?
- Which tools/approaches should be used?
- What are the major bottlenecks in all these aspects (examples of countries' points of view)?

The breakout session of the second day addressed the gaps in the appropriation of the science base of nutrient management by policy makers. The questions discussed were the following:

- Have past or on-going assessments of nutrient loads to water bodies sufficiently covered needs of policy making? Which gaps still need to be addressed (e.g. scale, data)?
- What does prevent the adoption in national action plans of measures (e.g. green and grey infrastructure) that research has shown to have the greatest potential to improve nutrient efficiency and recovery?
- How should EU and national sectoral policies be organized to ensure an integrated management of the various nutrient sources? Is there any evidence of this happening?
- Are subsidy-based approaches more effective than regulatory instruments?

The discussion in the breakout sessions is summarised in the following part.

Definition and main goals of Macro-Regional Integrated Nutrient Management

The Macro-Regional Integrated Nutrient Management was defined as a holistic approach for the management of nutrients (nitrogen and phosphorus in particular) that is based on a scientific assessment, includes the needs of different stakeholders and socio-economic sectors, and integrates sectoral policies affecting nutrients. The approach should be multi-element (considering the interaction of nitrogen and phosphorus with the other nutrients, such as carbon and silica) and multi-compartment. It should take into consideration sectoral policies dealing with different economic sectors, such as agriculture, energy and water policies, and integrate them also in space, considering the upstream-downstream relationships along the river basin.

The ultimate goal of Integrated Nutrient Management should be the protection of the environment while assuring the benefits and the protection of the people, which involves healthy environment, food and water security, economic security for farmers and the other stakeholders. Integrated Nutrient Management should aim at reducing the damage from nutrients. To achieve these goals it is necessary first to determine current status of the water bodies and second to reduce the land-based emissions in the areas under high pressure.

Sectors, institutions and stakeholders

The relevant stakeholders from local to macro-regional level are: farmers or small-scaled producers, farmer unions, agricultural cooperatives, municipalities/local authorities, central ministries and local/province representatives/institutions relevant to water, agriculture and environment, NGOs, agricultural industries, aquaculture sector, tourism sector, water suppliers/sectors, other industrial sectors.

The institutions dealing with the management of nutrients are often those involved in the spatial planning. Countries have different ways of organization of the institutions. For example, in Slovenia, where there are no regions, there is a gap between the municipality and the national level in the implementation of policies related to nutrients. In Denmark, the law on nutrient management is set at the national level and then it is applied at the regional level through municipalities. This double level, government and municipalities (which then talk to farmers) has revealed to be successful in the reduction of nutrient pollution. However, this structure might not be appropriate for a country, as the Netherlands, where the information is not shared between municipalities and farmers. In Montenegro, most of the funds are administrated at the national level, rather than at the municipality level, but at present municipalities do not have the knowledge to support the farmers in improving nutrient management. The situation is different in France, where municipalities have much more authority in controlling nutrient pollution, although they have not always shown to be successful in controlling land-based nutrient pollution, sometimes because of local economic interests.

Whatever the country institution organisation, it appears that municipalities can play a key role in the implementation of integrated nutrient management strategies. However, there is also a clear need of coordination at higher level by the national governments and the EU or international conventions, especially for macro-regional approaches.

The difficulty in communication between stakeholders and in knowledge sharing between researchers, policy makers and farmers, has been highlighted as a bottleneck for the implementation of Integrated Nutrient Management. In particular, the communication to farmers regarding sustainable practices for reducing land-based nutrient emissions is fundamental to improve nitrogen and phosphorus use efficiency.

Approaches and appropriate spatial and temporal scales

The appropriate scale for Integrated Nutrient Management should be the catchment scale. Several countries reported that in many cases water issues are still managed according to administrative borders. The common idea that emerged from the groups' discussion is that waters have to be managed by the river basin authorities, under the coordination of relevant ministries or the national authority.

Regarding the temporal resolution, there is often a discrepancy between the temporal frame in a biophysical assessment and the policy horizon. Generally, politicians are interested in short term results, mainly related to government election cycles, while managing the excess of nutrients in river basins requires a long-term vision because of the processes involved and the challenge of climate change adaptation.

Different models, ranging from simple lumped models to complex models can be useful tools to support Macro-Regional Integrated Nutrient Management. Among others, the models web platform for the Baltic Sea and the model Global NEWS were mentioned. However, there is a risk associated with uneducated users, who could apply the models without considering its conceptual limitations. This is the case, for example, when assessing the effects of fertiliser reduction using a model that does not include crop yields in the analysis.

In addition, an appropriate monitoring network should be in place. This can inform the analysis of the current status, as required by the Water Framework Directive, and inform distributed models and spatial planning. The national monitoring network should be sufficient and sustainable in terms of appropriate spatio-temporal resolutions. Examples were reported from Denmark, where a new plan is currently in place to map the farms distance to water bodies vulnerable to nutrient pollution, and from Turkey, which has started an ambitious programme of mapping farmers' parcels to control measures implementation and reduce land fragmentation. Similarly, Slovenia is planning to target measures according to the different soil types, while other European countries have designated all the national territory as Nitrogen Vulnerable Zone, to ensure the same conditions on fertiliser application to all farmers.

How to integrate objectives of EU and non-EU policies

In the European Union some policies are implemented in isolation or even in competition. But within the EU there is an interest in carrying out a horizontal implementation of the different policies. To support Macro-Regional Integrated Nutrient Management, synergies between directives and policy strategies should be strengthened, for example, between the Water Framework Directive, the Nitrates Directive and the Common Agricultural Policy.

Many Enlargement and Integration countries are including objectives of EU policies, such as the Water Framework Directive, in their national legislation. This integration presents additional challenges.

The results of twining projects and implementation of EU directives (such as the Water Framework Directive, the Nitrates Directive, the Urban Waste Water Directive and the Flood Directive) ongoing in Turkey show a concrete initiative for the adaptation and integration of non-EU national policies to EU policies.

The experience from the Baltic Sea has shown that all stakeholders should be involved to facilitate an agreement on a common goal for the reduction of land-based nutrient emissions. Countries in the HELCOM Convention set specific targets on nitrogen and phosphorus, based on reduction of loads back-calculated, and selected simple indicators for measuring the progress in achieving the targets. The following step was the analysis of the most cost-efficient strategies to achieve the targets. However, it took several years for the countries to "start speaking the same language". Then the role of the Convention is to report every five years on the status of the implementation and bring the message to the politicians.

Non-EU Balkan countries are considering the Water Framework Directive because they are involved in the Danube macro-regional strategy. It was suggested that the European Commission could steer and catalyse the work of the Black Sea Convention, as for the

Mediterranean Horizon2020 programme, where Arabic countries of the Mediterranean region are eligible for specific actions.

Information and assessment needs

Overall, nutrient loads and processes at the scale of river basins are known. However, less knowledge is available on field scale processes, including effects of soils, management, and especially hydrologic pathways (e.g. maps of tile drainage features/density), as well as on response time of measures (e.g. lags due to groundwater residence times). Usually drivers different from agriculture and human emissions are not addressed (e.g. lifestyle, diet). In addition, there is a general lack in the quantification and valuation of pollution impacts, essential for setting management targets.

Assessments based on models need to gather more robust data evidence, including statistics on fertilizers, arable land, crops, often taken just from relatively coarse sources such as EUROSTAT or FAO, but issues with reliability of data may be present (e.g. laboratory intercalibration) as well as with the monitoring design. For example, in some cases, the pollution problem has been resolved by stopping the monitoring in the critical areas, in others by multiplying the monitoring points in water bodies of good quality.

Some additional shortcomings are observed that limit the development of Macro-Regional Integrated Nutrient Management strategies. From the policy side, the lack of communication and data sharing across country borders; from the scientific side, the bias towards scientifically interesting questions rather than policy-relevant questions.

Some experiences from countries were reported. In Slovenia, the monitoring network is sufficient, while the information on the share represented by each nutrient source is missing. In Ukraine, although the monitoring data are the same, the assessment and reporting strategy to the ICPDR and the national government are different, conveying a different message. In the USA, they adopt a different strategy, starting from the impacts (algal blooms in coastal areas) and then looking at the responsible sourcing areas. In Serbia, the monitoring network is probably sufficient, but data on mineral fertiliser and manure application are not available, which prevents policy makers from having a correct understanding of the pollution problem.

Obstacles to adoption of best measures

Some elements that can prevent the adoption of best measures for Integrated Nutrient Management are the following:

- Lack of sufficient financial budget;
- Difficulties in addressing the right people that takes the decisions at the policy and administrative level;
- Turnover of politicians, that is too short for them to feel committed in nitrogen reduction plans over the medium-long term;

- Lack of education on nutrient best management practices and environmental protection; cultural habits (e.g. farmers not trusting the public sector); mismanagement on nutrients application (e.g. insufficient assessment of soil phosphorus stocks; field tests not shared by farmers);

- Marginalization and aging of the farmers.

For the successful implementation of best measures the awareness and contribution of farmers is crucial. In this respect, a network of demonstration sites (and farmers training in place particularly in autumn and spring) has been suggested as a useful action, following the positive example of Nordic countries.

Incentives and regulations

Experiences from countries were reported. In Denmark the regulations on measures to reduce nutrient emissions to water bodies were more efficient than the incentives on setting buffer strips. Differently, in Turkey, subsidies worked better than the penalties. In Italy, the situation was similar to Denmark, but the regulation has also stimulated self-sustained buffer strip cropping (e.g. for fuel wood).

Demand side management could work better than subsidies, like in France where farmers pay for water irrigation, as in this way there is a balance between the supply and the demand side.

If adopted, subsidies should go together with an appropriate monitoring and control system, measuring the right variables. In particular, indicators of sustainable development should be used. The problem arises when there is a disconnection between subsidies to the agricultural sector and the water quality, as happening in the Po plain (however, the new CAP requires the cross compliance to obtain the subsidies).

Regarding the payment of services versus the compensation, the former stimulates ownership of actions by farmers. Countries decide how much to pay, and use the payment of services as a potential tool for tailored actions as well as making all values of environmental services explicit, not just the monetary value (e.g. pollination, recreation, and increase of productivity/land value).

Other instruments to reduce nutrient pollution could be the adoption of green labels, in which industries could be involved, and a more homogeneous regulation on organic farming across Europe. The example of the ban of phosphate detergents in the Danube countries, following a decision of the ICPDR, has shown that industries are willing to collaborate provided that a clear regulation framework is enforced and it is the same across all regional countries.

Integration of EU and national sectoral policies to ensure Integrated Nutrient Management

There are still some bottlenecks for the integration of EU and national sectoral policies to ensure Integrated Nutrient Management:

- Division of responsibilities. Often different national agencies are in charge of different aspects of the nutrient management (such as monitoring, water quality, water quantity, etc.), in this situation it is difficult to identify the ultimate responsible for the implementation.

- Financial management. Revenues from the water sector might be collected centrally by a ministry different from that responsible for water quality protection and only partially redistributed to the local authorities responsible for the implementation (this is the case in Serbia, Montenegro and other Danube countries). For example in France, the revenues from the water sector are collected by the major river basin authorities, which are then responsible for using and investing the budget. Similarly, in Croatia some progress in assigning the responsibility to the two main river basins has been done. Instead in Slovenia, a bottom up approach is adopted. Revenues from the water sector are collected and invested in projects proposed by local municipalities, but upon decision of the central government.

- Coordination and communication. Even, when the responsibilities and budget are managed at the level of the river basin authority, coordination among the different river basins is needed, especially for Macro-Regional Integrated Nutrient Management.

- Responsibility for past pollution or transboundary pollution. For example, the Iron Gate reservoir in Serbia has accumulated sediments and nutrients from the other countries and past management decisions, and it is difficult to identify the responsible for the pollution.

- Spatial scale of sectoral policies. For the nitrogen atmospheric pollution the river basin scale it is not the preferred spatial scale, creating issues of integration between water and air/climate pollution policies.

Political will and economic benefits are the key elements to succeed in the implementation of Integrated Nutrient Management. Revenues from the sector should be reinvested at the river basin level and agencies need to have coordination at the high level to tackle pollution in seas and atmosphere.

How to make politicians listening (a part from the economic argument)? The prospective of getting some level of association or membership of the EU is a good incentive for some countries. For example, Turkey is trying to implement the EU directives into the national policy. Norway is also adopting the EU legislation, because they consider it is an effective tool to protect and improve the environment.

4. Recommendations and way forward

The general recommendations that emerged from the discussion in the Workshop can be summarized as follows:

- Assessment is an essential step for the formulation of measures leading to an integrated nutrient management. Yet, building on existing knowledge base, efforts should go beyond characterisation (a favourite field of action for natural scientists) to proposals for solutions (the playground of decision makers). The latter should also include suggestions for innovative approaches to nutrient efficiency.
- Analyses of trade-offs and ecosystem services would aid decision makers design effective nutrient management plans more than further in-depth understanding of nutrient dynamics.
- Diffuse agricultural sources and urban point sources are the major contributors of nutrients to the overall nutrient cycle. However, integrated nutrient management should adopt a cross-sectoral approach leading to a circular nutrient economy. This requires horizontal integration of sectoral policies (e.g. water, air, agriculture, industry).
- Macro-regional Strategies offer an opportunity to link EU Member States and Enlargement and Integration countries in the achievement of common objectives concerning reduction of nutrient loads to water bodies (the Baltic[4], the Danube[5] and the Adriatic-Ionian[6] Strategies identify management of nutrient flows as priority actions).
- Building on the discussion and recommendations that emerged in the workshop, the participants expressed the interest in collaborative actions on Macro-Regional Integrated Nutrient Management. One concrete action proposed, involving representatives from Italy, Croatia, Slovenia, Montenegro, Serbia and the JRC, concerns the preparation of a roadmap to assess the nutrient loads to the sea in the Adriatic and Ionian area that could support the recent European Union Strategy for the Adriatic and Ionian Region. The other countries present at the Workshop are already involved in a similar activity in the framework of the EU Danube Strategy, and discussion took place on collaboration with Turkey for the assessment of current and future loads of nutrients to inland and coastal water bodies.

[4] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, European Union Strategy concerning the European Union Strategy for the Baltic Sea Region, COM(2009) 248 final, and following reports

[5] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, European Union Strategy for Danube Region, COM(2010) 715 final

[6] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions concerning the European Union Strategy for the Adriatic and Ionian Region, COM(2014) 357 final

APPENDIX A

AGENDA

Workshop
Managing Nitrogen and Phosphorus Loads to Water Bodies:
Towards Macro-Regional Integrated Nutrient Management
14-15 July 2014, JRC-IES, Ispra, ITALY
PROGRAMME

DAY 1 : MONDAY 14 July 2014 (Building 36, ROOM 2)	
08:15	Bus from the hotel to the JRC, registration at the reception and transport to the meeting room
09:00	Welcome and Framing of the Workshop **Giovanni Bidoglio, Faycal Bouraoui,** Joint Research Centre, European Commission
	SESSION 1: Managing Nitrogen and Phosphorus Loads to Water Bodies: Policies & International Initiatives
09:20	Nutrient Pressures on Water Resources : EU Policy Framework **Francesco Presicce,** DG Environment, European Commission
09:40	Global Nutrient Cycle Project **Albert Bleeker,** Energy Research Centre of the Netherlands
10:00	The International Nitrogen Initiative - A Framework of International Activities to Tackle Environmental Impacts of Nitrogen **Wilfried Winiwarter,** International Institute for Applied Systems Analysis
	SESSION 2: Countries' Experience & Perspectives
10:20	Country presentations: • Bulgaria (**Olga Nitcheva**, Bulgarian Institute of Meteorology and Hydrology) • Croatia (**Milan Mesic**, University of Zagreb)
10:50	***Coffee break***
11:20	Country presentations: • Italy (**Marco Bartoli**, University of Parma) • Moldova (**Tamara Leah**, Institute of Pedology-Soil Science) • Montenegro (**Ivana Bajković**, Water Directorate of Montenegro) • Romania (**Elvira Marchidan**, National Administration "Apele Romane")
12:30	***Lunch buffet***
13:30	Country presentations: • Serbia (**Marko Pavlovic**, Republic Hydrometeorological Service of Serbia) • Slovenia (**Matjaž Glavan**, (University of Ljubljana, Environmental Planning) • Turkey (**Metin Türker**, Ministry of Food Agriculture Livestock) • Ukraine (**Andriy Demydenko**, IPMMS-Cybernetics Center)
15:30	***Coffee break***

	Working Groups: Addressing the Macro-Regional Dimension of Integrated Nutrient Management
15:45	**Working Group 1** / **Working Group 2**
17:45	Reporting back from working groups and discussion
18:00	End of Day 1
18:15	Bus from the JRC to the hotel
20:00	***Networking dinner***

Day 2 : TUESDAY 15 July 2014 (Building 36, ROOM 3)	
08:15	Bus from the hotel to the JRC and transport to the meeting room
	SESSION 3: Integrating Science and Policy
09.00	Integrating Science and Policy for Using Wetlands for Controlling Eutrophication of Downstream Aquatic Ecosystems: Three Case Studies in the USA **William J. Mitsch,** Florida Gulf Coast University, USA
09:20	Management of Nutrient Losses in Denmark **Brian Kronvang,** Aarhus University, Denmark
09:40	Mitigation Options to Reduce Nutrient Losses from Land to Surface Water **Oscar Schoumans,** Wageningen, Netherlands
10:00	Temporal Changes in Nutrient Concentrations and Losses from Agricultural Streams in the Nordic and Baltic Countries **Per Stålnacke,** BIOFORSK, Norway
10:20	Nitrogen and Phosphorus in Europe's Waters: Integrated Assessment **Faycal Bouraoui,** Joint Research Centre
10:45	***Coffee break***
	Working Groups: Developing Recommendations for an Integrated Macro-Regional Management of Nutrients
11:00	**Working Group 1** / **Working Group 2**
12:30	Reporting back from working groups and discussion
13:00	***Lunch at the JRC Canteen***
14:30	General discussion and perspectives **Giovanni Bidoglio,** Joint Research Centre, European Commission
15:15	Tour of the JRC Vistors' Centre
15:45	Bus from the JRC Visitors' Centre to the Hotel

APPENDIX B

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Abstract

Joint Research Centre organized a workshop bringing together scientists, policy makers and water managers to exchange experiences on the approaches presently used in Enlargement and Integration countries and in EU 28 Member States in controlling nitrogen and phosphorus emissions from human land-based activities. The Workshop intended to progress from characterisation to solutions linking European and country scales (where decision making takes place) to the watershed and farm scales (where implementation happens). It also addressed the need of a macro-regional approach to nutrient management, as nutrient pollution often goes beyond country borders and requires coordinated cross-sectoral actions to prevent solutions transferring problems from one economic sector or environmental compartment to another.
The workshop was structured into three main sessions featuring a series of presentations given by scientists, policy makers and country representatives. The first session aimed at characterizing the current policies and international activities on nutrient management. In the second session the current profiles of nutrient loads to water bodies and national policies in Enlargement and Integration countries and selected EU Member States were presented. The third session concentrated on how to strengthen the knowledge base of integrated nutrient management as a support to policy making. Breakout groups were also organised to allow participants to discuss countries' experiences and perspectives and identify recommendations for follow up actions, aim at improving integration of activities in Enlargement and Integration countries and EU Member States.
This report presents the contributions from the participants (Section 2), then the discussion in the breakout sessions (Section 3), and finally the recommendations that emerged from the Workshop (Section 4).

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