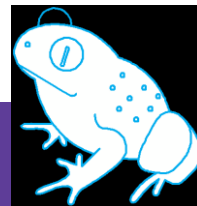
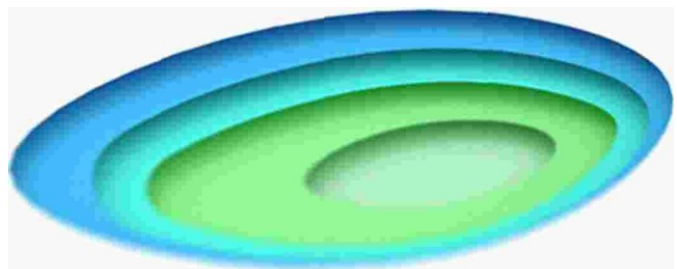
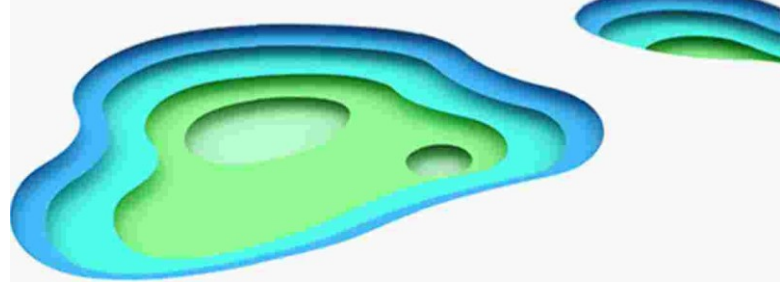
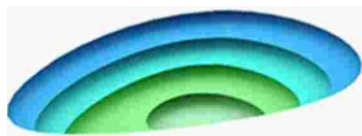


ABSTRACT BOOK

University of Algarve
Faro, Portugal



**12th ANNUAL SWS
EUROPEAN CHAPTER MEETING**
May 4th-6th 2017



12th Annual SWS European Chapter Meeting - Abstract book

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12TH SOCIETY OF WETLAND SCIENTISTS EUROPE CHAPTER MEETING	99
Workshop Committees.....	100
Welcome	101
Programme	102
 Abstracts of plenary lectures.....	 104
PL B2 - Society of Wetland Scientists Promotes Wetland Science: Current Actions, Projects and Programs	105
PL A - Doñana, on the tightrope	107
PL D - Opportunities for paludiculture	113
PL B1 - Ramsar Convention: conservation of wetlands for a better, more sustainable world	115
PL C - Removal of Pharmaceuticals in Constructed Wetlands	116
Abstracts of oral communications	119
C4 - Can health risk perception act as a tool in wetland management?	120
E1 - Selecting the right reed for paludiculture – The importance of a plant’s phenotypic plasticity.....	122
A2 - Introduction of Characteristics of Coastal Wetlands in Yemen	124
D4 - Deterioration of fen ecosystems at Catfield Fen (Norfolk, UK)	128
C3 - Phenolic compounds in seven macrophytes in the Czech Republic	130
F2 - Rare earth elements and Yttrium partition and fractionation in salt marsh sediments colonized by halophytic vegetation	132
B4 - Integrated constructed wetlands for mine-influenced water	139
A7 - Assessing wetland status and trends: Issues, challenges and SWS initiatives	141
C1 - Sea level rise impacts on estuarine salt marshes - A multi-disciplinary approach	142
D6 - Effects of climate-driven invasion of mangroves on C and N cycling processes in salt marshes.....	144
E4 - Diversity of macrophytes in waterbodies conditioned by riverine water	146
A6 - The distribution of ponds in northern Poland: order and chaos.....	148
A1 - Wetlands status and trends in the Mediterranean region	153
B1 - Adaptation of water framework indicators (phytoplankton and nutrients) for oligohaline and mesohaline Mediterranean lagoons	160

12th Annual SWS European Chapter Meeting - Abstract book

D2 - Challenges encountered in reanimating wetlands – Reflecting on 30 years of effort ...	166
C5 - From wastelands to the Land of Fortune: Perceptions and consistencies about wetlands in Uganda	169
D1 - Plant species used in floating treatments wetlands: A decade of experiments in North Italy	171
F3 - Monitoring an early stage constructed wetland for the abatement of pollutants in agricultural drainage water	173
D8 - Nutrient contribution by breeding waterbirds at Lake Lesser Prespa (Greece) and their influence on the water quality variables	175
A3 - Remote sensing for the wise use of wetlands: 25 years of landscape changes in the Kilombero floodplain, Tanzania	176
A5 - Island wetlands of Greece - From ignorance to international recognition	179
F1 - How is metal speciation affected by halophyte cover in different morphology salt marshes?.....	189
E2 - New data on distribution of <i>Apium repens</i> (Jacq.) Lag in the Slunjčica River, Croatia	191
B3 - Comparison of vegetation on three recovering milled peatlands in comparison with pristine bogs	193
D5 - A cheap and cheerful way to improve water quality and enhance biodiversity: The Frogshall Integrated Constructed Wetland	197
A4 - Testing (new, easy, efficient) tools for assessing the ecological status and threats of Mediterranean wetlands	199
E5 - Wilde Mulde - re-vitalisation of a dynamic riverine landscape and possible effects on sediment and contaminant dynamics in floodplains	200
D3 - <i>Typha latifolia</i> : The importance of phosphorus co-limitation of the leaf photosynthesis-nitrogen relation and growth	201
B2 - Polyphenols as enzyme inhibitors across a gradient of low to highly degraded peat soils: Implications for microbial metabolism in rewetted fens	203
D7 - The differences of peat and water quality of degraded and natural peatlands in northern and central Europe with special emphasis on phosphorus, nitrogen and carbon	205
B5 - Macrophytes in small lentic waterbodies between Adriatic, Alps and Pannonian lowland	207
Abstracts of oral communications	210
SWS PST 1 - Studenchishte wetland on the shore of Ohrid Lake: The process of its degradation studied by remote sensing	211
SWS PST 2 - Stress tolerance in pre-conditioned plant populations through Pulse Amplitude Modulated (PAM)	213
SWS PST 3 - Duckweed (<i>Lemna minor</i> L.) – An experimental plant for phytoremediation of dairy effluent	214

**7th European Pond Conservation Network Workshop + LIFE CHARCOS Seminar
and 12th Annual SWS European Chapter Meeting - Abstract book**

SWS PST 4 - Development of forshore mires in humic lakes of NE Poland	216
SWS PST 5 - Bird conservation in Lesser Prespa Lake: Benefiting local communities and building a climate change resilient ecosystem. LIFE+ project (2016-2021) - Experiment management and restoration of reedbeds for waterbirds	219
SWS PST 6 - Adsorption of Linear Alkylbenzene Sulfonates on Wetland Soils obtained from Karlovac area (Croatia)	220
SWS PST 7 - The Waterharmonica: (re)use of treated waste water through natural processes also in the Algarve, Portugal?	222
SWS PST 8 - Cyanobacteria in small water bodies: the effect of habitat and abiotic factors	229
SWS PST 9 - Restoring Wetlands in Kampinos National Park – Chances and Challenges..	232
SWS PST 10 - Water fluxes and nutrients loading: A tool for wetland restoration in Albufera of Valencia	233
SWS PST 11 - Different phenotypic traits among nine phylogeographic groups of <i>Phragmites australis</i> in a homogeneous environment	235
SWS PST 12 - High nutritional value of fish farmed in Veta la Palma.....	237
SWS PST 13 - The influence of extreme hydrological condition on phytoplankton community structure in protected sections of two lowland rivers	150
Author's Index	240



12th Society of Wetland Scientists Europe Chapter Meeting

4th – 6th May 2017
Universidade do Algarve, Faro, Portugal

Organizers:



Workshop Committees

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Kara Miller (SWS secretariat)
Keith Edwards (University of South Bohemia, Czech Republic)
Matt Simpson (WWT, UK)
Jos Verhoeven (Utrecht University, The Netherlands)
Lina Lopes (Untapped Events, Ltd)

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Jan Vymazal (Czech University of Life Sciences, Czech Republic)
Eva Hernandez (WWF Spain)
Hans Joosten (University of Greifswald)
Gillian Davies (SWS President)
Martha Rojas-Urrego (RAMSAR Convention Secretary General)

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Luis Cancela da Fonseca (University of Algarve, Portugal)
Maria Isabel Violante Caçador (University of Lisbon, Portugal)

Welcome

It is a great pleasure to welcome you all to Faro in the beautiful Algarve for our 12th SWS Europe Chapter meeting. Our meetings always have a characteristic spirit of focus on wetland science and its relevance for practitioners and have always sought interaction with wetland conservation and management areas in different parts of our continent. In the program of the current meeting you will recognize that same willingness to explore the connection between science and practice, with focus areas such as wetland conservation and tailored management, wetlands for water quality enhancement, wetland ecological functions and services and the emerging field of paludiculture. We will have three key-note lectures introducing these themes including one about the winding road to effective protection and conservation of the Doñana wetland just across the Spanish border.

We are very pleased that the President of SWS, Gillian Davies, has accepted our invitation to attend the meeting. Last year, past-president Kim Ponzio attended our meeting in Potsdam, which has strengthened the bonds of our chapter with the leadership of the society. We hope that we can continue to work closer together to make our chapter grow and take the society further on the path of internationalization. Gillian will also be in Faro to take part in the signing of the renewed Memorandum of Cooperation between SWS and the Ramsar Convention. The Secretary-General of this Convention, Martha Rojas-Urrego, will also be in Faro, so that our Europe Chapter meeting will set the stage for this signing ceremony. It is our hope that the MoC between the two organizations will also contribute to scientific and sound wetland management, and to the designation of additional Ramsar wetlands around the world.

Our Europe Chapter has also enhanced collaborative activities with related European organizations to join forces and strengthen each other's meetings and long-term objectives. We are grateful for the effective collaboration with the European Pond Conservation Network in the organization of this meeting in Faro. The local EPCN membership in Faro has coordinated and organized all local facilities and activities in the region, also for the SWS meeting. We acknowledge this good and pleasant partnership! In addition, the SWS Europe Chapter will sign MoCs with the International Wetland Pollutant Dynamics and Control Symposium (WETPOL) and the Constructed Wetland Association (CWA) during the meeting.

It is our hope that through all these initiatives, wetland science and its applications in the worlds of conservation, (water) resource management and wise use will thrive and move towards a new level.

Keith Edwards
Matt Simpson
Jos Verhoeven

Programme

May 4th

- 08.30-18.30 Field Trips
18.00-20.00 Registration
20.00 Conference Dinner

May 5th

- 08.00-08.30 Registration
08.30-09.00 Welcome session
09.00-10.00 **Eva Hernández** "Doñana, on the tightrope" - **Chairperson Laura Serrano**
10.00-10.30 Poster session
10.30-11.00 Coffee
11.00-13.00 Oral session A - Ecological quality and conservation of wetlands – **Chairperson Laura Serrano**
A1 - *Grillas, P.* - Wetlands status and trends in the Mediterranean region
A2 - *Al-Mahfadi, A.S.M.* - Introduction of Characteristics of Coastal Wetlands in Yemen
A3 - *Muro, J.* - Remote sensing for the wise use of wetlands: 25 years of landscape changes in the Kilombero floodplain, Tanzania
A4 - *Sahuquillo, M.* - Testing (new, easy, efficient) tools for assess the ecological status and threats of Mediterranean wetlands
A5 - *Giannakakis, T.* - Island wetlands of Greece. From ignorance to international recognition
A6 - *Golus, W.* - The distribution of ponds in northern Poland: order and chaos
A7 - *Davidson, N.* - Assessing wetland status and trends: issues, challenges and SWS initiatives
13.00-14.00 Lunch
14.00-15.30 **Martha Rojas-Urrego** "Ramsar Convention on Wetlands of International Importance" - **Chairperson Jos Verhoeven**
Gillian T. Davies "Society of Wetland Scientists Promotes Wetland Science: Current Actions, Projects and Programs" - **Chairperson Jos Verhoeven**
15.30-16.45 Oral session B - Ecological quality and conservation of wetlands
B1 - *Grillas, P.* - Adaptation of water framework indicators (phytoplankton and nutrients,) for oligohaline and mesohaline Mediterranean lagoons.
B2 - *Zak, D.* - Polyphenols as enzyme inhibitors across a gradient of low to highly degraded peat soils: Implications for microbial metabolism in rewetted fens
B3 - *Purre, A.* - Comparison of vegetation on three recovering milled peatlands in comparison with pristine bogs
B4 - *Carty, A.* - Integrated Constructed Wetlands for Mine-influenced Water
B5 - *Zelnik, I.* - Macrophytes in small lentic waterbodies between Adriatic, Alps and Pannonian lowland
16.45-17.15 Coffee
17.15-18.30 Oral session C - Ecological quality and conservation of wetlands - **Chairperson Jos Verhoeven**
C1 - *Caçador, I.* - Sea level rise impacts on estuarine salt marshes - a multi-disciplinary approach
C3 - *Vymazal, J.* - Phenolic compounds in seven macrophytes in the Czech Republic
C4 - *Anthonj, C.* - Can Health Risk Perception act as a Tool in Wetland Management?
C5 - *Heinkel, S.* - From Wastelands to the Land of Fortune: Perceptions and consistencies about wetlands in Uganda
18.30-20.00 **SWS Europe Business Meeting**

4th – 6th May 2017
12th Society of Wetland Scientists Europe Chapter Meeting

May 6th

- 08.00-09.00 Registration
- 09.00-10.00 **Jan Vymazal** "Removal of Pharmaceuticals in Constructed Wetlands" – **Chairperson Matt Simpson**
- 10.00-10.30 Poster session
- 10.30-11.00 Coffee
- 11.00-13.00 Oral session D - Wetlands and water quality – **Chairperson Matt Simpson**
- D1 - *Ibrahim, H.M.S.* - Plant species used in floating treatments wetlands: A decade of experiments in North Italy
- D2 - *Harrington, R.* - Challenges encountered in reanimating wetlands – reflecting on 30 years of effort
- D3 - *Sorrell, B.* - *Typha latifolia*: The importance of phosphorus co-limitation of the leaf photosynthesis-nitrogen relation and growth
- D4 - *Barendregt, A.* - Deterioration of fen ecosystems at Catfield Fen (Norfolk, UK)
- D5 - *McInnes, R.J.* - A cheap and cheerful way to improve water quality and enhance biodiversity: the Frogshall Integrated Constructed Wetland
- D6 - *Verhoeven, J.T.A.* - Effects of climate-driven invasion of mangroves on C and N cycling processes in salt marshes
- D7 - *Zak, D.* - The differences of peat and water quality of degraded and natural peatlands in northern and central Europe with special emphasis on phosphorus, nitrogen and carbon
- D8 - *Maliaka, V.* - Nutrient contribution by breeding waterbirds at Lake Lesser Prespa (Greece) and their influence on the water quality variables
- 13.00-14.00 Lunch
- 14.00-15.00 **Hans Joosten** "Opportunities for paludiculture" – **Chairperson Rob McInnes**
- 15.00-15.30 Poster session
- 15.30-16.45 Oral Session E - Paludiculture and River Conservation – **Chairperson Rob McInnes**
- E1 - *Eller, F.* - Selecting the right reed for paludiculture – the importance of a plant's phenotypic plasticity
- E2 - *Popović, N.* - New data on distribution of *Apium repens* (Jacq.) Lag. in the Slunjčica River, Croatia
- E4 - *Germ, M.* - Diversity of macrophytes in waterbodies conditioned by riverine water
- E5 - *Schulz-Zunkel, C.* - Wilde Mulde - re-vitalisation of a dynamic riverine landscape and possible effects on sediment and contaminant dynamics in floodplains
- 16.45-17.15 Coffee
- 17.15-18.00 Oral Session F - Wetlands and water quality – **Chairperson Rob McInnes**
- F1 - *Pedro, S.* - How is metal speciation affected by halophyte cover in different morphology salt marshes?
- F2 - *Brito, P.* - Rare earth elements and Yttrium partition and fractionation in salt marshes sediments colonized by halophytic vegetation
- F3 - *Ibrahim, H.M.S.* - Monitoring an early stage constructed wetland for the abatement of pollutants in agricultural drainage water
- 18.00-20.00 Goodbye

Abstracts of plenary lectures

PL B2 - Society of Wetland Scientists Promotes Wetland Science: Current Actions, Projects and Programs

Davies, G.T.^a

^aSociety of Wetland Scientists, President BSC Group, Inc. Worcester, Massachusetts, USA

The SWS Mission is, “To promote understanding, conservation, protection, restoration, science-based management, and sustainability of wetlands”. Our Europe Chapter actively promotes wetland science and conservation both within Europe and around the world, sharing knowledge, insight and friendship with colleagues from all corners of the world.

As a matter of fact, at this particular juncture in history, membership and active involvement in societies such as the Society of Wetland Scientists is more important than ever. We are faced with the greatest ecological challenge of all time – a climate that is changing at an accelerating pace.

The conservation, restoration and protection of wetlands and other ecosystems is essential if we are to slow the advance of climate change, due to the ability of ecosystems, especially wetland ecosystems, to accumulate and store carbon from the atmosphere. To add to this challenge, around the world, we see many nations turning inward and away from science.

As scientists, we have invested our careers and our spirits in the pursuit of, and application of, science and knowledge, in the hopes that greater understanding will lead to a brighter future for our planet. The work that we do as individuals is important and counts. But it is only when we act in concert, come together as a scientific community, and share what we have learned, that we reap the greatest rewards and make the most progress forward. Membership in the Society of Wetland Scientists provides a means of joining a vibrant and active international community of fellow wetland scientists, with a myriad of ways to learn, to connect with your colleagues, and to amplify the impact of your work by active participation in meetings, the *Wetlands* journal, the *Wetland Science and Practice* publication, webinars, leading or participating in student opportunities, and more.

In this presentation, many SWS opportunities for involvement will be highlighted, as will some of the actions, projects, and programs that SWS members and leaders have engaged in recently, such as:

- Collaborating with the Ramsar Convention on Wetlands, Society for Ecological Restoration, INTECOL, etc.
- Promoting science-based policy and conservation efforts involving Lake Ohrid/Studentchista Marsh in Macedonia, the Jiading Wetland in Taiwan, and SWS work with our Consortium for Aquatic Science Societies partners in the U.S.
- Supporting wetland scientists in the developing world
- Offering student opportunities such as the new SWS Wetland Ambassadors Program
- Enhancing diversity by supporting underrepresented students and professionals

- Developing an international Professional Certification Program – Coming to Europe!

Now more than ever, we need you to join the Society of Wetland Scientists, not just for your benefit, but in order to amplify your work and your voice, our work and our voice, on behalf of wetlands and sustainable, science-based policy, conservation, protection, restoration, and management around the world. Please take this opportunity to join SWS. Membership information is available on our website: www.sws.org

PL A - Doñana, on the tightrope

Hernández, E.^a, Carmona, J.^b, Fuentelsaz, F.^b, Seiz, R.^a, Schmidt, G.^c, and
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^bWWF Spain, Doñana Office, Hinojos, Spain;

^c Fresh Thoughts, Vienna, Austria; ^d Independent consultant, Spain

INTRODUCTION

The clock is ticking against Doñana, one of the last big coastal wetlands remaining in Europe, and the first one in WWF's agenda since the creation of the organization in 1961. Urgent action is needed to save the site from collapsing.

The protection of Doñana as a National Park, for which the role of WWF was key, meant the elimination or strong limitation of many threats, such as drainage for agriculture, eucalyptus plantations, beach resorts, roads to ensure the maintenance of a unique landscape. Additional recognition of the value of the site was awarded by the designation as Ramsar Wetland of International Importance, Biosphere Reserve and World Heritage Site.

The protection of Doñana meant also a new step in wetlands research, with the creation of the Doñana Biological Station (Estación Biológica de Doñana), strongly fostered by the visionary naturalist Luc Hoffmann. The situation seemed ideal: legal protection and an innovative research center.

Despite the knowledge and the protection, the threats have continued to grow around Doñana, like in many other parks in the world. Roads, mining, navigation, gas abstraction and storage, agriculture... Many activities have intensified the use of natural resources and put pressure on the natural functioning of the ecosystems, affecting especially the availability and quality of water and their connectivity. Adding global change variables to this equation, results in the slow but continuous erosion of the biodiversity and the alteration of natural processes, taking Doñana to the verge of collapse.

The protection was the solution 60 years ago. Now the challenge – and the opportunity – is in the management. Several European Directives – especially Birds and Habitats Directive and Water Framework Directive – if properly implemented, together with an extensive scientific knowledge, provide key tools for better conservation and integration of the management of the site with that of the surroundings, and with the future challenges to become linked to global change. Urgent actions need to be taken and agreed from all sides to ensure a future for Doñana: public administrations in- and outside the protected area, businesses, civil society and, of course, scientists.

ANALYSIS OF THE CURRENT SITUATION

The responsibility of being a flagship wetland

Little remains to be said about the values of Doñana. It is one of the most important natural areas in Europe, due to its unique biodiversity and ecosystems that conform the outstanding landscapes that, in the past century and still today, made naturalists fall in love with it and fight for its protection. Stop-over point for millions of migratory birds

and breeding site for thousands, and last refuge of many threatened species, Doñana is a flagship and a magnet for communication. It is special and, therefore, its management should also be an example to inspire other protected areas. The opportunity for benchmarking is there, and regional – as well as national - administrations should grab it before it is too late.

Doñana is not doing fine

In 2016 WWF compiled the most recent and complete information on the conservation status of water habitats and species in Doñana, revising numerous scientific publications, analyzing the current management plans, and holding meetings such as the *Doñana Water Workshop*, with leading scientists to validate and complete the information gathered under the report *Status of Water in Doñana* ([Estado del Agua en Doñana. Una evaluación del estado de las aguas y los ecosistemas del espacio protegido](#)). The main conclusion from the experts was that the state of conservation of Doñana is clearly worse than reflected in official planning documents and urgent action needs to be taken.

The deterioration of the aquifer, especially from the quantitative point of view, is very alarming. The latest government status report on the Almonte-Marismas aquifer, presented by the Guadalquivir River Basin Authority in July 2016, confirms the continuous declines of groundwater levels, which are very steep in some areas. This official report continues to ignore the effects of this decline on ecosystems.

Literature shows, and workshop experts confirm, that the aquifer deterioration is affecting rivers, wetlands, vegetation and fauna of Doñana in general, and lagoons, specifically. The streams that reach the marshland are receiving much less water than they used to from the aquifer, and in some areas, close to farming land, groundwater flows have been substituted by irrigation run-off. In the zones where the decrease of the water table has been more intense, streams have dried out and cork oaks are dying. The lowering of the water table is also most probably behind the change of vegetation in the coastal areas, with an increase of the extensions of sabines. A change has also been detected in the composition of the vegetation of the marshlands, and on land from the so called “monte negro” (dense shrub land dominated by *Erica scoparia*, more dependent on higher humidity in the soil) towards intermediary shrub land (a transition to “monte blanco”, or white shrub land, more open and adapted to droughts). But the most evident consequences of the lowering of the levels of the aquifer is the reduction of the hydroperiod of the lagoons in the park. While temporary ones are drying out, the only permanent lagoon in the protected area, Laguna de Santa Olalla has now become temporary, with its flooding levels increasingly depending on rainfall. These lagoons are the last refuge for many threatened species of macrophytes, rotifers and zooplanktonic crustaceans.

Another major problem is the pollution of ground and surface water by nutrients, agrochemicals and, in certain areas, heavy metal pollutants from industrial sources. The excessive intake and release of nutrients in the marsh, in particular, is leading to a rapid eutrophication, speeded up in the last five years, and to deterioration of vegetation, as well as the spread of invasive species at the expense of native species. The lower part of the Partido stream, for example, now lacks macrophytes due to the excessive load of nutrients. In the marshland itself, the invasive fern *Azolla filiculoides* continues increasing its cover, and 96% of the fish biomass corresponds to invasive species.

Eutrophication processes are also linked to a higher risk of epizootic processes, increasing the mortality of anatids, and affecting specifically those species with weaker populations: the red-knobbed coot (*Fulica cristata*), the white-eyed pochard (*Aythya nyroca*) or the marbled teal (*Marmaronetta angustirostris*), the three species listed under the Annex I of the European Birds Directive, due to their special needs of conservation.

Regarding transitional waters, the current poor morphology and water quality of the Guadalquivir River estuary poses a risk to the necessary reconnection of Doñana with the river. The estuary receives now 60% less freshwater than it used to 70 years ago, and 5 times less than it would need; it has lost 85% of its coastal floodplains and all its arms; and there is no balance between the sedimentary and hydrological dynamics, increasing turbidity – which causes that light penetration is 20 times lower than in similar estuaries, reaching 40 times lower during Spring -, increasing hypoxia and hypercapnia, which in turn reduces species richness and increases presence of toxic phytoplankton. This lack of balance is also causing the erosion of the river banks and coastal sandy areas. The result is an estuary with a chronic reduction of biodiversity and fisheries potential.

Overall, the poor state of Doñana's waters has resulted in the deterioration of plant, invertebrate - with a clear example of dragonflies, a group that has lost 12 species since the late 50's -, fish –with three species not seen since 2002 - and bird populations. Despite the increase of Ardeidae and ibis populations, notable is the decline of wintering ducks in the natural marsh area and those species that feed on macrophytes or their seeds, as well as nesting ducks and coots, which include some endangered species.

The effects of climate change, in addition, are exacerbating the effects of the pressures Doñana is suffering. The increase of the temperature already detected in the area seems to be speeding up eutrophication processes and blooms of invasive species, and combined with a decrease in rainfall, it is expected to cause a further decline in the recharge of the aquifer that would imply a lowering of the water table of up to 17 meter by 2080.

The causes of a chronic disease

The erosion in the biodiversity values and natural processes of Doñana is of course the result of a long journey. The huge political and economic pressures focused on short term benefits, have during many years fed the belief that Doñana could be saved just by putting a fence around it and managing its interior. The still low awareness of local populations of how important the ecosystems of Doñana are for their livelihoods and quality of life, has also been nurtured by the public administrations through their decisions. On one hand, intense – and necessary - programs were set to get the inhabitants of Doñana to know the beauty of Doñana, and huge investments were done for restoration activities – also very much needed -, while on the other hand new roads were built, new impacting activities were authorized and no action was taken to stop illegal water abstraction or land reclamation.

Right now, the legal framework – especially European - and the accumulated knowledge should be enough to take Doñana on a safe path. The public administrations involved in and affecting Doñana need to accept the challenge and properly implement the Habitats and Water Directives - the infringement procedures opened by the European Commission against Spain show that this has not happened yet -, and make

use of all the available information. There is a lot of information to be used, as was made visible with the analysis developed by WWF.

However, the lack of reliable data about fundamental aspects such as the water balance of the marshlands, or water withdrawals for agriculture severely hampers management and proper monitoring of the evolution of this wetland. As the *Hollis Report* already highlighted 25 years ago, there remains a fundamental challenge to improve the knowledge about Doñana.

The river basin water plan and the protected area management plans have been developed on an inadequate dataset and incomplete or simplified assessments. This is the combined result of failures in establishing monitoring networks, difficulties due to the complexity of the system, and lack of interest or political will.

Not having all the data, or disregarding the facts, has led the government to intentionally make a positive interpretation of the state of ecosystems and water bodies. This has resulted in a lower commitment to implement control measures on serious pressures that threaten Doñana. The outcome is the continued deterioration of the entire ecosystem, and the repeated non-compliance with national, European and international conservation commitments.

The current situation of Doñana has led UNESCO - with the support of IUCN - and the secretariat of the Ramsar Convention to send two international missions to Doñana, in 2011 and 2015. Additionally, the UNESCO World Heritage Committee has approved several decisions requesting Spain to take action for the protection of the aquifer and the estuary, and to make a clear and permanent commitment against the dredging of the Guadalquivir River.

A WAY FORWARD

The conservation of Doñana, therefore, requires urgent measures to be coordinated between all parties involved. The responsibility is shared, and both basic and applied research, in natural and social sciences have a lot to contribute here.

The “to do list” of the Authorities, on one side, is long. It includes the implementation of brave measures to recover the aquifer, improving the quantity and quality of the waters reaching the marshlands, and the firm commitment against the deepening of the dredging of the Guadalquivir estuary. But probably the main challenge is the implementation of a new kind of management, one aimed at gaining resilience and not just “conserving”, keeping Doñana within its “safe operating space”, one that considers the 9 planetary boundaries considered safe for the human being and the prosperity of the site itself. At the same time, it is key to involve all sectors and local populations in reaching the same objectives, sharing responsibilities. As it was agreed in the *Doñana Water Workshop* organized by WWF, the first step is the definition of a solid framework, with clear, detailed and ambitious conservation objectives, as well as a monitoring program tailored to the needs of the protected area’s management.

On its side, scientific research has to provide robust data that help in defining those objectives and in monitoring the wetlands. Science cannot fly solo, independent of the needs of the management, a dialogue must be established so both parts feed mutually.

The dialogue must also be established within science itself. Working in silos does not allow for the necessary identification of the relationship between the changes in the state of conservation of habitats and species, and the pressures affecting them.

Finally, science, scientists, need to speak up. The eternal further need of information cannot be alleged as an excuse not to make a call for action to the managers, and the society, a call also to apply the precautionary principle in their decisions, and remind us all of the danger in which wetlands in general –and Doñana in particular- are and what impact that would have in our lives. Without wetlands, after all, there would be no wetlands science.

ACKNOWLEDGEMENTS

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Thanks, finally, to all the colleagues at WWF Spain and WWF International, who support the work we do in Doñana, the ones that did in the past, and the ones that will come, since the path of conservation implies a long term commitment.

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PL D - Opportunities for paludiculture

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INTRODUCTION

The origin of mainstream western agriculture lies in the ‘Fertile Crescent’ and domesticated species from the Middle East currently constitute major cereal, legume and fibre crops. This ‘semi-desert’ origin installed the paradigm that productive land must be dry, which has ever since been applied also to wet, organic soils.

Lowering the peatland water table leads to enormous emissions of greenhouse gases (GHG) and nutrients. Globally, drained peatlands (0.4 % of the land) are responsible for 5% of all anthropogenic GHG emissions; in 25 countries drained peatlands emit >50% compared to national emissions from fossil fuels & cement.

Drainage-induced oxidation and compaction furthermore leads to progressive subsidence, which increasingly complicates gravity drainage, eventually forces the instalment of expensive polder systems, and increases the risk of floods and salt water intrusion. In continental and warmer climates, drained peat soils become fine-grained, irreversibly hydrophobic and unsuitable for agriculture. Abandonment and lack of control may then lead to catastrophic peat fires.

Awareness of these problems is maturing and worldwide thousands of square kilometres of drained agricultural peatlands have already been taken out of production and rewetted.

The quest for productive land, however, also intensifies rapidly because of population growth, the demands for more food security and welfare, and the necessity to replace fossil by renewable resources (cf. Paris Agreement). Both persisting use of drained peatland and conversion of agricultural peatland to unused wetlands imply a loss of productive land in a time that we need it most. Therefore new agricultural techniques have to be developed that allow continuing production while simultaneously restoring or maintaining the ecosystem services of wet peatlands.

The concept of paludiculture

In contrast to conventional drainage-based agriculture, paludicultures (Latin ‘palus’ = swamp) utilise biomass from wet and rewetted peatlands. In the temperate and (sub)tropical zones, peat is mainly formed by roots and rhizomes, which may allow harvest of above-ground biomass without frustrating peat formation and conservation. In various countries paludicultures are being tested, building on traditional usage of spontaneous wetland plants for food, feed, fibre and fuel, but also by cultivating selected wetland crops for novel applications such as biofuel, construction materials, growing media, and pharmaceuticals. The keynote will present an overview of current implementation initiatives and research experiences.

Central in the concept of paludiculture are the pursued synergies with other ecosystem services. Compared to drained peat soils, paludicultures may support preservation and sequestration of carbon, climate change adaptation by evaporative

cooling, flood control, water purification, and conservation of peatland typical flora and fauna. These ecosystem services are increasingly identified, quantified, monetarised and commodified. Practical experiences and model calculations indicate that paludicultures often can compete with drainage-based peatland use, certainly when external costs are adequately considered and perverse incentives are removed.

Outlook

The area of drained peatlands in the world exceeds 500 000 km². Paludicultures thus offer wide opportunities for restoration of degraded land and for multifunctional land use, which are paramount in times of increasing land scarcity. Research, development and realisation are not only necessary for the temperate zone, where paludicultures will mainly be implemented on formerly drained land. Especially in the tropics, paludicultures are required as an alternative for rapidly expanding unsustainable drainage-based agriculture and forestry. Various conditions, however, still hamper large-scale implementation.

Rewetting of peat soils will often involve large-scale hydrological restructuring and land re-allotment. Paludiculture furthermore implies major changes in operational management and substantial investments in adapted machinery making a change to paludiculture virtually irreversible for individual enterprises.

Laws, regulations and subsidies still largely fail to accommodate for paludiculture and have to be adjusted, whereas those that perversely stimulate peatland drainage need to be abolished. Payments for ecosystem services have to be implemented to reward external benefits.

Last but not least, large-scale implementation of paludiculture requires a change in agricultural education, training and mind-set away from drainage towards a positive attitude to wetland agriculture.

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PL B1 - Ramsar Convention: conservation of wetlands for a better, more sustainable world

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The Ramsar Convention's mission is “the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world”. Today the Convention has 169 Contracting Parties across the world who have designated more than 2,220 wetlands for special protection as “Ramsar Sites”, covering 214 million hectares.

Wetlands have never been more relevant to climate change adaptation and mitigation and sustainable development as they are today. They play a vital role for humanity by providing all our water and food. Well-managed wetlands make communities resilient in the event of extreme weather and help to minimize the damage from these hazards. Wetlands absorb and store carbon, which makes them a vital asset for countries pursuing the Paris climate agreement's targets for reducing CO₂ emissions.

However, wetlands are being destroyed or degraded faster than any other ecosystem. Latest figures show that 64% of the world's wetlands have disappeared in the last century, and that every year we lose 1% of those remaining.

Some studies have indicated that ecosystems provide at least US\$ 33 trillion worth of services

annually, of which about US\$ 4.9 trillion are attributed to wetlands. Recognition and valuation of the diverse values that wetlands provide is needed to secure the sustainable use of wetlands, and enhance wetlands' contributions to global policy processes, such as the 2030 Agenda for Sustainable Development and the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, and the Paris climate agreement. The Ramsar Convention on Wetlands and its 4th Strategic Plan for 2016-2024 is an ideal vehicle to help countries to meet targets of the global sustainable agenda.

Scientific input and technical information play a crucial role in this process. The Society of Wetland Scientists with its 3,000 members worldwide continues to lead wetland science by developing and communicating critical information for further policy development.

By signing a Memorandum of Cooperation for 2017-2023, the Ramsar Convention on Wetlands welcomes the opportunity to strengthen collaboration with the Society of Wetland Scientists as an essential partner to achieve the Convention's vision for a better, more sustainable world where healthy wetlands provide our economic and social security.

PL C - Removal of Pharmaceuticals in Constructed Wetlands

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INTRODUCTION

The term Emerging Pollutants primarily refers to those for which no regulations currently require monitoring or public reporting of their presence in our water supply or wastewater discharges. Many constituents described as emerging pollutants are pharmaceuticals and personal care products (PPCPs) that may enter the environment through excretion in human and animal urine and feces, through flushing of unused medications, household uses, or bathing, and result in ng/L to µg/L concentrations in the environment. Emerging pollutants have the potential to enter the environment and cause known or suspected adverse ecological and (or) human health effects. In some cases, release of emerging pollutants to the environment has likely occurred for a long time, but may not have been recognized until new detection methods were developed (Table 1).

Pharmaceuticals started to attract public attention as emerging aquatic micropollutants in the late 1990s (e.g., Halling-Sørensen et al., 1998; Ternes, 1998). The most targeted pharmaceuticals belong to several groups of substances, namely pain relievers, antibiotics, antiepileptics, antiphlogistics (NSAID), antibacterial agents, anticoagulants, beta blockers, antiepileptics, diuretics, fibrates (lipid regulators), psychoactive drugs (stimulants) and most recently also antidepressants (Table 1).

Table 1. Examples of the first introduction to the market for substances of various groups of pharmaceuticals.

Marketed			
Compound	Action	Since	As (examples)
Paracetamol	Pain reliever	1893	Tylenol, Panadol, Paralen
Sulfanilamide	Antibacterial	1936	
Penicilin G	Antibiotics	1942	Penicilin G
Warfarin	Anticoagulant	1954	Coumadin, Jantoven
Hydrochlorothiazide	Diureticum	1959	Apo-hypo, Aquazide, BPZide
Carbamazepine	Antiepileptikum	1962	Tegretol
Ibuprofen	NSAID	1969	Brufen, Advil, Nurofen
Metoprolol	Beta-blocker	1969	Lopressor, Metolar XR
Bezafibrate	Fibrates	1977	Bezafibrate, Caberzol
Sertranile	Antidepressant	1991	Zoloft

Pharmaceuticals are excreted by humans in varying degrees of degradation and discharged directly into the sewerage systems and consequently to wastewater treatment plants. Some of these compounds degraded naturally through hydrolysis, biodegradation, or direct and indirect photolysis (Morrall et al., 2004), while others have the potential to be adsorbed and eliminated from aqueous environments (Yamamoto et al., 2009). The first attempts to evaluate constructed wetlands (CWs) with respect to removal of pharmaceuticals from wastewaters were carried out in USA (Gross et al., 2004) and Spain (Matamoros et al., 2005).

So far, various types of constructed wetlands have been used to evaluate removal of pharmaceuticals, namely free water surface and subsurface-flow (both horizontal and vertical) constructed wetlands (e.g. Verlicchi and Zambello, 2014). Until now, more than 100 pharmaceuticals have been monitored in about 80 constructed wetlands studies. The most commonly monitored compounds are NSAID (nonsteroidal anti-inflammatory drugs), namely ibuprofen, ketoprofen, diclofenac and naproxene, antiepileptic drug carbamazepine and stimulant caffeine, which, indeed, is also present in many commonly used drinks.

The available results indicate that the removal efficiencies are highly variable among studies and there is probably a wide array of parameters that can influence the removal. These parameters include chemical structure and physical-chemical properties of the compounds, redox conditions in the wetlands, temperature, filtration material or inflow loading among others. The treatment efficiencies of constructed wetlands reported in the literature for various pharmaceuticals are unanimous, however it seems that the efficiency of constructed wetlands is comparable with conventional activated sludge systems.

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4th – 6th May 2017
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Abstracts of oral communications

C4 - Can health risk perception act as a tool in wetland management?

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INTRODUCTION

Worldwide and particularly in East Africa, the growing food insecurity and water scarcity have increasingly been motivating people to settle along wetlands and make use of their abundant water resources and ecosystem services. In the course of this extensive occupational and domestic use, the capacities of wetlands are often depleted by overuse, making them become more and more ‘unhealthy’. In particular, the degradation and contamination of water, as well as poor infrastructure, pose a range of risk factors that potentially expose users to water-related diseases. Health risk assessments in wetlands are scarce to date, and in order to fill this gap, an assessment of risk perceptions in wetlands, referring to subjective judgements of individuals towards health hazards they might be exposed to, is vital. Although the pivotal role of health risk perception for health risk behaviour and management is widely acknowledged, the extent to which wetland users are aware of use-related risks has not been studied so far. Such research, however, should be considered in a sustainable management of wetlands.

METHODS

A study conducted in the semiarid highland floodplain Ewaso Narok Swamp, Kenya, addressed water-related diseases in wetlands, assessed the related health risk perception by wetland users and evaluated their health-related behaviour. A mixed-method approach included a broad set of empirical data collected during a household survey (n=400), observational assessment (n=397) and in-depth interviews (n=20) conducted among the four most prominent user groups around the wetland, namely smallholder farmers, commercial farmers, pastoralists and service sector workers. A triangulation of quantitative and qualitative results is presented.

RESULTS and DISCUSSION

Wetland users are aware of numerous diseases that the use of the swamp may expose them to. Especially unsafe water, inadequate sanitation and poor hygiene (WASH) are being perceived as responsible risk factors for diseases in the Ewaso Narok Swamp. As summarized by one pastoralist in the Ewaso Narok Swamp

‘...the quality of water is poor now, it is not as good anymore because of the water contamination. A lot of people right now are using this water and it is coming from way up there [the Aberdare Ranges]. We lack good sanitation, latrines and the bathrooms, so we have to go to the wetland for the services and we also let the animals drink from there. So this situation just contaminates the whole water. Water is the main problem in this area. It’s dirty, water is the major cause of diseases in this area. The water is so little and it’s the same water we are using for everything, for the livestock, wild animals, and with the farmers for irrigation, so it’s posing as a challenge for us.’

Moreover, the wetlands' water resources providing mosquito breeding sites are rated as harmful. Occupational factors, such as the use of pesticides in agricultural crop production and environment- and climate-related features are widely perceived risk factors as well.

Different diseases are associated with different risk factors: Malaria is mostly associated with mosquito breeding sites, but also with flooding and rain, the proximity to rivers, as well as unsafe water and inadequate sanitation. Diarrhea is mostly linked to unsafe water and inadequate sanitation, but also to poor hygiene. Moreover, rain is attributed as a major risk factor, as well as pesticide use. Eye diseases are first and foremost associated with the use of pesticides, but also with unsafe WASH, with swimming in wetland water and with drought. Skin diseases also are perceived to be caused especially by poor hygiene, unsafe water and inadequate sanitation, and also by the use of pesticides.

A health risk assessment relating self-reported abdominal conditions, fever, flu, skin and eye conditions of wetland users to multiple occupational and domestic WASH-related risk factors reveals that the actual risks correspond with the perceived risks. The analysis reflects the perceptions of the wetland users, demonstrating that the use of safe water, adequate sanitation and good personal hygiene and other health-protective measures such as environmental hygiene, the prevention of uncovered stagnant waters in the compound, the use of mosquito bed nets, play a key role in preventing ill-health. It also shows that in the case of the Ewaso Narok Swamp, unsafe WASH involves a higher risk than occupational factors.

CONCLUSIONS

This case study shows that wetland users are aware of water-related health risks contributing to the burden of disease. Many of the perceived risk factors, first and foremost the contamination of water, are created and exacerbated by the wetland users through their unhealthy behaviour, which originates mainly in the limited infrastructural and educational possibilities. In an area where improved water sources and sanitation facilities, as well as hygiene options are largely lacking, and where hygiene education is very limited, the perceptions of health risks can hardly motivate a change of behaviour.

However, as demonstrated here, risk perception studies are able to reflect the actual risks, as well as the shortcomings of an area, such as a WASH-wise underserved wetland. The role of wetland users as key informants should be acknowledged by wetland managers: Since the trend of increasing wetland use is unlikely to be reversed but rather most likely to be exacerbated, there is the need to capture the challenges that wetland communities are facing in order to facilitate healthy wetland use, decide on the way forward or on possible interventions. This makes risk perception studies a potential supportive tool for health- adapted sustainable wetland management that includes users as participants and actors.

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E1 - Selecting the right reed for paludiculture – The importance of a plant's phenotypic plasticity

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INTRODUCTION

Paludiculture is the wet cultivation of re-wetted marshland. *Phragmites australis* (common reed) is a promising paludicultural candidate species for bioenergy and construction purposes, due to its high biomass production and worldwide occurrence. However, *P. australis* also has a significant intraspecific variability resulting in markedly differing phenotypes, not all of which may be suitable for the application in paludiculture. We here aimed at investigating the acclimation capacity of different populations of *P. australis* to different nutrient and temperature regimes. The best-suited population would be the one yielding high biomass already at medium nutrient levels, and having a high plasticity to temperature as buffer against changing climatic conditions.

METHODS

Growth at different nutrient levels

Four different populations of *P. australis* from Europe were grown at five nutrient levels in a mesocosm experiment over the course of one growing season. At the end of the growing season, the above- and below-ground parts of the biomass were harvested and their dry masses determined.

Plasticity and acclimation to different growth temperatures

Three different populations of *P. australis* from Europe, North America and China, originating from a wide latitudinal gradient, were grown in growth chambers at three daytime temperatures of 18 °C, 26 °C and 34 °C. Photosynthesis rates, growth traits and biomass production were measured after several weeks of growth. A plasticity index was calculated for every measured parameter and correlated with the geographical origin of the plants to assess whether populations from a certain latitudinal range have a higher phenotypic plasticity to temperature changes than others.

RESULTS and DISCUSSION

We found that the European reed populations differ widely in their responses to nutrient availability. The Romanian and Italian populations yielded high aboveground biomass, but also decreased their ratio of below ground: above ground biomass in response to nutrient availability, thereby decreasing their carbon storage for the following growing season. This may result in lower yields if a lower nutrient input is expected in the following growing season. Allocation to leaves also differed between the populations. Since leaves contain a large pool of a plant's nitrogen, different populations

may be chosen for cultivation depending on nitrogen availability in the soil, the production purpose and desired N-content of the yield.

All three reed populations in the temperature-experiment increased their growth and biomass with increasing temperatures, even those from cold temperate origins. *Phragmites australis* is therefore not a species that is threatened by the rise in the global temperature. Shoot production and elongation showed higher plasticity with increasing latitude. Hence, reed populations of more northern origin are best suited to acclimate to temperature fluctuations.

CONCLUSIONS

The choice of reed populations for paludiculture will depend mainly on local availability, but given the high intraspecific variability between populations from different regions, focus should be on choosing reeds optimal for the end-use of the paludiculture product (e.g. bioenergy or other uses) at the specific climatic and environmental conditions. Populations of higher latitudes are probably better suited against temperature fluctuations than populations from lower latitudes. Some populations will have high biomass yields, but only if nutrient availability is stable and high. A mixture of different populations can probably be recommended but needs further investigation.

ACKNOWLEDGEMENTS

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A2 - Introduction of Characteristics of Coastal Wetlands in Yemen

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ABSTRACT

Wetlands have considerable importance as biodiversity holders (habitats, animals and plants), while they provide several resources and benefits to local communities in different parts of the world. In addition, wetlands can buffer pollutions, absorb floods and recharge aquifers.

Yemen has been identified as hosting globally important biodiversity, thanks to its situation at the crossroads between the Afrotropical, Oriental and Palearctic regions. This biodiversity is particularly rich in coastal wetlands, given that the coastline of Yemen is over 2500 km long and overlapping three different seas with different characteristics: Red Sea, Gulf of Aden and Arabian Sea.

Despite this richness both in patrimonial and social resources, these wetlands are under threat, causing a permanent ecological imbalance in their biodiversity. Urban and industrial pollutants affect increasingly several coastal wetlands, while wetland habitats are continuously lost under pressure of urbanization, agriculture, dams, water derivation, drainage, covering; all these impacts are amplified by recurrent droughts.

This means that urgent solutions are needed to conserve wetland biodiversity in Yemen, as well as in other regions of the world; these should be found primarily through strategic action planning, both on national and local levels. However, this tool should necessarily be based on basic information, and more especially on spatial tools used in wetland Characteristics and inventory. That's why our research on coastal wetlands was focused on geospatial information, which provides a global understanding of the Characteristics and general physical functioning of these ecosystems.

The work started by reviewing recent **literature** on the wetland classifications which has been used to get a general idea on wetlands types present in Yemen.

However our research aims to find an automatic Characteristics based on watershed criteria more than on local characteristics. Most of the information was extracted from **geospatial tools**, mainly (MNT), Google images, Rainfall images.

This research was focused not only on coastal wetlands but it also presents a general data on dams. This was based both on personal mapping and existing data and literature. It also describes the general configuration of hydrographic networks. In addition to map tools specific to each wetland, results are synthesized and discussed, in a way to help different agencies for wise use of wetland resources. Finally, recommendations to guide decision-makers for initiating a process of sustainable development are given.

Further research could focus on investigating how achieve the sustainable management for different wetlands.

Keywords: Coastal Wetlands, Classification, Inventory, Watersheds, mapping, Yemen.

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D4 - Deterioration of fen ecosystems at Catfield Fen (Norfolk, UK)

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INTRODUCTION

Catfield Fen is a well-known area for fen conservation in the Norfolk Broads (UK) which historically is famous for its diversity in plant and animal species.

Catfield is protected nationally (SSSI) and internationally (Habitats Directive, Birds Directive, Ramsar) but in recent years a reduction in botanical diversity has been reported, that might be related to increased groundwater abstraction locally. This provides the motivation for research to investigate current conditions in the fen. Giller & Wheeler (1986, 1988) offer fine descriptions from fieldwork in the beginning of the 1980-ies and we compare present conditions and processes with that period.

METHODS

Fen peat chemistry was investigated in April 2014 at six sites, comparable with Giller & Wheeler (1988), in transects at 5m intervals (horizontally) water samples and measurements of EC in the soil at 20 cm intervals to a depth of 2m. Vegetation was recorded every 5m. In addition, the wider hydrological setting was characterised using available hydrological data.

RESULTS

The special ecological condition in Catfield Fen in the 80-ies was the presence of calcareous fen vegetation with *Cladium* and *Carex*-species with isolated “islands” of acidophilic species, such as *Sphagnum*-mosses and the fern *Dryopteris cristata*. It appeared that these acidophilic species have expanded over most of the fen area in 2014. Surface pH-values in the rich fens had fallen from 6.7 to 6.2 and in poor fens from 5.4 to 4.6. Profile studies showed that the first 20 cm were acidified at many locations, whereas at a depth of 1m the calcium-rich groundwater was mostly dominant.

Hydrological research indicates a mix of precipitation and groundwater flow from the adjacent elevated areas into the fen area. However, by variation of clay layers in the subsoil this flow is only locally prominent (Gilvear et al., 1997). The hydrology of the system is influenced by groundwater abstraction in the elevated areas which commenced around 1980, resulting in reduced groundwater discharge especially in dry summer conditions.

DISCUSSION

The result of the hydrological change in the system is that less calcium-rich groundwater discharges into the area of calcareous fen vegetation and at the surface more rainwater accumulates. After 30 years the acid component at the soil surface

becomes more dominant and the buffer capacity changes, and rather suddenly the vegetation changes in a few years from a rich fen to a poor fen. It seemed that a tipping point in fen development was passed. This was observed and by comparing the 2014 data with the descriptions with Giller & Wheeler (1986, 1988); this change was confirmed by changes in water chemistry and by the presence of plant species. Although the specially protected acidophilic species have increased in extent, there have been reductions (in presence and number) of important rich fen species.

The conclusion is that groundwater abstraction is the main cause for the deterioration of the fen. The literature suggests that not only desiccation was a problem in fens of the Norfolk Broads (Fojt, 1994), but impacts of groundwater abstraction have been mentioned also (Harding, 1993). When licences for groundwater abstraction adjacent to Catfield Fen came up for renewal, the owners of the Fen started a legal procedure to stop the abstraction. The final inquiry with all stakeholders resulted in September 2016 and confirmed the impact of groundwater flow and the closing of the abstraction. This local impact may have future consequences for the Norfolk Broads as there are many abstractions for drinking water and agriculture in the whole region.

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C3 - Phenolic compounds in seven macrophytes in the Czech Republic

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INTRODUCTION

Phenolics are very important for plant biochemistry and physiology. They are involved in many interaction of plants with the biotic and abiotic environment. Phenolic are the most widely distributed class of plant secondary metabolites and higher plants are able to produce several thousands of different phenolic compounds (Lattanzio, 2013).

It has been reported that phenolics are more resistant to decomposition due to the negative impact on the microorganisms involved. The effects of polyphenols on soil microorganisms were reviewed by many researchers, for example Kuiters (1990) or Hättenschwiler and Vitousek (2000). According to these studies the most resistant compounds to decompose in plants are phenolics. Therefore, it may be hypothesized that the higher content of phenolics in plant tissue the slower decomposition rates and potentially higher carbon sequestration in the soil. Therefore, it is very important to know the phenolics content in various plants. The primary goal of this study was to evaluate and compare the content of phenolics in seven common macrophytes in the Czech Republic.

METHODS

Aboveground biomass of seven common wetland plants was sampled in June 2016 at six different localities. The macrophytes involved in the survey were *Phragmites australis*, *Phalaris arundinacea*, *Typha latifolia*, *Glyceria maxima*, *Scirpus sylvaticus*, *Carex nigra* and *Juncus effusus*. Harvested biomass was separated into stems and leaves and dried to a constant weight at 60 °C. In the biomass, C, N, P and phenolic contents were determined. Total C and N were determined using the TC/TN analyser. Total P was determined according to Sommers and Nelson (1972) and phenolics were determined by spectrophotometric methods according to the Folin-Ciocalteu method (Bärlocher and Graca, 2005). Several plants were also harvested in August and October in order to follow a seasonal pattern (data not shown in the abstract).

RESULTS and DISCUSSION

Concentration of total phenolics varies among surveyed species and in various plant parts as well (Fig. 1). The lowest concentrations were found in stems of *P. australis* followed by stems of *P. arundinacea*. The highest concentrations were observed in *Carex nigra* and *Scirpus sylvaticus*. According to the other results it seems, that concentration of phenolics in plants decrease during the season and it is also effected by the conditions in the site of growth (results are not shown). The similar results were reported by Harrison et al (2017). They found that some wetland plants vary in total

foliar phenolic content relative to environmental factors. The concentration values found in our study are comparable with those reported in the literature.

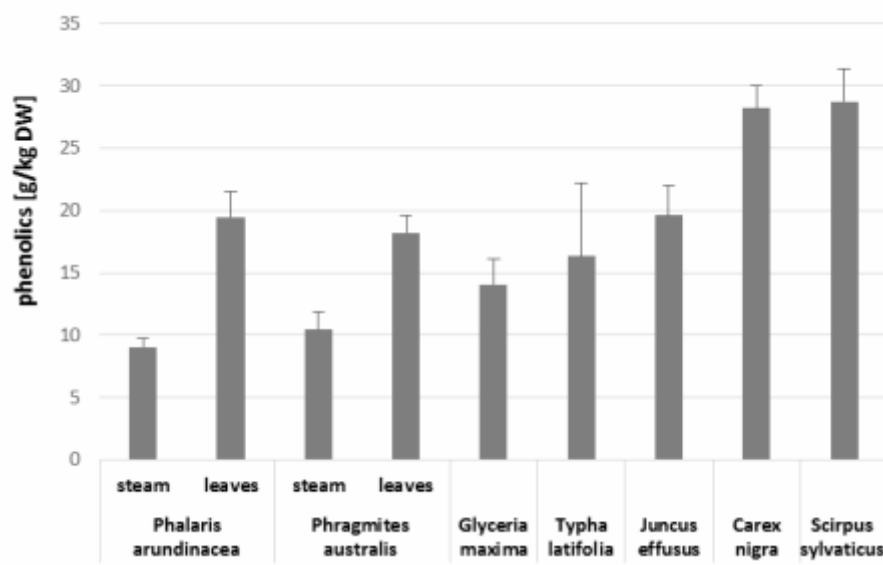


Fig. 1. Concentrations of total phenolics in seven macrophyte species sampled in June 2016 in six different localities of Czech Republic.

CONCLUSIONS

According to this study it is evident that different wetland species have different concentrations of phenolics. Moreover it seems that the concentrations are different in the various plant parts.

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F2 - Rare earth elements and Yttrium partition and fractionation in salt marsh sediments colonized by halophytic vegetation

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INTRODUCTION

Rare earth elements and yttrium (YREE) have been extensively studied in rivers, estuaries and coastal areas as geochemical tracers of sources and processes controlling trace element partition in sediments [1, 2, 3]. The YREE distribution is largely controlled by scavenging processes [4, 5, 6], by the overlying water column redox conditions [7], by the lithogenic sources composition [8] and by the inputs of potential anthropogenic [9]. Several works have been reported on anomalous YREE concentrations in river, estuarine and marine sediments, caused by anthropogenic inputs derived from human activities (e.g. agriculture, ore mining, industrial plants and urban Waste Water Treatment Plants (WWTP) [10, 11, 12, 13].

Salt marshes have been suggested to act as natural sinks for metals [14, 15, 16]. These low hydrodynamic estuarine areas are close to heavily populated areas and receive important discharges of different sources (e.g. agriculture diffusive leaching and urban WWTP effluents) [17, 18, 19]. Rare earth elements, in both dissolved and particulate forms, are transported by currents, and eventually incorporated on sediments [20]. Salt marsh halophytic vegetation act as sediment traps [21], playing an important role in the settling of suspended material and their associated metals. Metals, incorporated in both organic and inorganic forms in sediment, may be available for uptake by plant roots. The complex reactions involving natural organic matter in the sediments may play a key role in controlling the metal bioavailability [22]. Beyond organic matter input, halophytic vegetation appears to have an important role in the metal cycling as root-induced changes in the rhizosphere modify substantially the redox status, pH and microorganisms. Metals may be uptake through the plants root system and subsequently incorporated in the other tissues [23, 24, 25].

The objective of this work was to perform a preliminary study on the YREE fractionation and transference between the rhizosphere and salt marsh plants and their translocation and fractionation from the roots to the aerial parts of plants. The study was carried out in the Castro Marim salt marsh - Guadiana estuary (Southwest Europe).

METHODS

Study area

The Castro Marim salt marsh is a 12 km² wetland on the south Portugal-Spain border, close to the Guadiana estuary mouth and consists of tidal flats, intertidal inlets, saltworks, tidal ponds, and two major sub-tidal inlets (Lezíria and Carrasqueira inlets) that cross the whole marsh and are inundated during high tide [26]. The two main

creeks also have season freshwater inflow that is higher during winter. This ecosystem is characterized by semi- diurnal meso-tidal regime (tidal range 1.22 to 2.82 m) [27]. Typical halophytic vegetation (*Sarcocornia fruticosa*, *Zostera noltii*, *Spartina maritima*, *Puccinellia maritime*, *Arthrocnemum perenne*, and *Spartina densiflorae*) covers the intertidal surface of the salt marsh, which is only completely inundated during spring tides.

The Guadiana River crosses extensive rural area and the basin is on massive sulphide deposits, the Iberian Pyrite Belt, with intense mining extraction since Roman Age [28, 29]. Pyrite extraction has ceased in the last decade. Besides this influence the estuary receives the urban sewages of two cities located near the mouth [30, 31]. Since 2002, more than 80% of the freshwater flow is regulated by a large dam constructed 140 km upstream the estuarine mouth, minimising the abrupt river discharges to the estuary.

Sampling and samples treatment

Halophytic plants (*Spartina maritima* and *Sarcocornia fruticosa*), colonized and non-colonized sediment cores were collected in Castro Marim salt marsh in February 2012. The aerial plant biomass was washed with ultrapure water (18.2 M Ω • cm) to remove particles, and were separated into photosynthetic and non-photosynthetic tissues. *S. fruticosa* does not have a true shoot system with leaves and stems. From this plant the swollen photosynthetic stems were separated from the dry perennial shoots. A similar procedure was followed for *S. maritima* where the tillers were divided in leaves and in non-photosynthetic tissues. Sediments were sliced in layers with 2-cm thickness up to 20 cm and 5 cm to the end of the core (approx. 30 cm). To obtain solid sediment and belowground biomass a 0.5 mm size sieve (Retch) was used and each layer were washed carefully under a flux of ultrapure water to separate biological material from sediments. After being washed, sediments and plants tissues were freeze-dried and homogenized in a mill (Retch, type MM200) prior to analysis.

Analytical techniques

For the metal analysis approximately 200 mg of plant material was digested with a mixture of HNO₃ (sp, 65% v/v) and H₂O₂ (sp, 30% v/v) at 60°C for 12 h and at 100°C for 1 h according to the method described previously [32]. Sediment samples were completely digested with 6 cm³ of HF (40%) and 1 cm³ of Aqua Regia (HCl-36%: HNO₃-60%; 3:1) in closed Teflon bombs at 100 °C for 1 h [33]. Both plant and sediment digested samples were analysed for YREE (Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu) by inductively-coupled plasma mass spectrometry (ICP-MS) using a Thermo Elemental, X- Series, following [34].

RESULTS and DISCUSSION

Yttrium and REE concentrations and fractionation in the sediment cores

The yttrium (Y) and total rare earth elements (Σ REE) contents and fractionation patterns in the non-vegetated and vegetated sediment cores are represented in Figure 1. Total rare earth element concentrations in the non-vegetated sediment core were lower than the values found in the vegetated material, ranging between 169 and 192 mg•kg⁻¹ (average value 179±6.1 mg•kg⁻¹) and 186 and 222 mg•kg⁻¹ (average value 211±7.4 mg•kg⁻¹), respectively. Depth profiles of Y contents showed the same trend varying from

16 and 19 mg•kg⁻¹ for the non-colonized core and 18 and 22 mg• kg⁻¹ for both colonized cores, respectively.

The PAAS-normalized sediment samples showed similar YREE patterns among the three sediment cores, with a slight enrichment in the light-REE (LREE) relative to the heavy-REE (HREE), where the (La/Yb)PAAS values obtained are above the unity (average value 1.2±0.04). An enrichment in middle-REE (MREE) was also observed in the three sediment cores, with higher (La/Sm) PAAS average values. This MREE increase, relative to LREE and HREE, has been associated with Fe-rich material in soils [35, 36]. Similar patterns were found in non-vegetated sediment cores collected in the Alcochete salt marsh (Tagus estuary) [37].

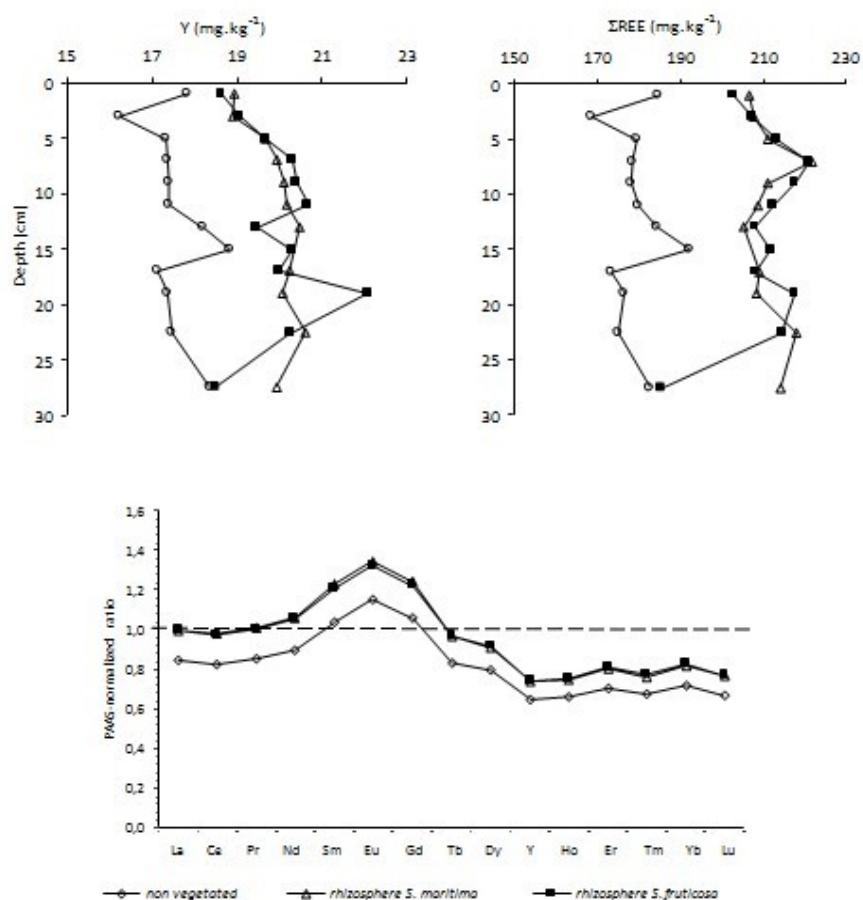


Fig. 1 Depth profiles of Y and total rare earth elements (ΣREE) contents (mg• kg⁻¹), and PAAS-normalized fractionation patterns in the non-vegetated and vegetated sediment cores from Castro Marim salt marsh.

Yttrium and REE concentrations and fractionation in the halophytic plants

The Σ REE concentrations in the salt marsh plants studied were, in general, lower relative to the contents found in the sediments (Fig. 2). Roots from *S. fruticosa* revealed slight lower Σ REE contents relative to the rizosphere until the first 5 cm of depth followed by a large increase, with values ranging from 134 to 368 mg.kg⁻¹. The *S. maritima* roots Σ REE contents were significantly lower relative to the previous halophytic species, with concentrations varying from 19 and 50 mg.kg⁻¹. The Y contents in the *S. fruticosa* roots followed a similar pattern, with lower values in the first 5 cm and a steep increase after, with contents varying from 12 and 35 mg.kg⁻¹, while

the *S. maritima* roots had much lower Y levels, ranging from 1.9 and 4.8 mg.kg⁻¹ (average value 3.2±0.92 mg kg⁻¹). Concentrations of Σ REE were significantly lower in the aerial organs of the plants with values of 2.1 and 2.4 mg.kg⁻¹, for the *S. fruticosa* and *S. maritima* stems, respectively, and 1.2 and 3.7 mg.kg⁻¹, for the leaves of these two species. These results are in agreement with other published studies where the REE contents decrease in the order root > leaf > stem [38, 39, 40, 41, 42].

The obtained results may suggest a higher ability for REE absorption from the rizosphere by the roots of *S. fruticosa* comparative to the *S. maritima*. Presumably the higher specific area of the belowground biomass of *S. fruticosa*, promotes the intense root-sediment interactions and consequently lead to higher accumulation in root tissues. Similar results were found for other transitional elements like Cd, Cu and Pb [43].

The PAAS-normalized YREE ratios showed similar fractionation patterns in both halophytic species roots, with ratios close to the unity for the *S. fruticosa*, while the *S. maritima* showed a general depletion relative to the PAAS series (Fig. 3).

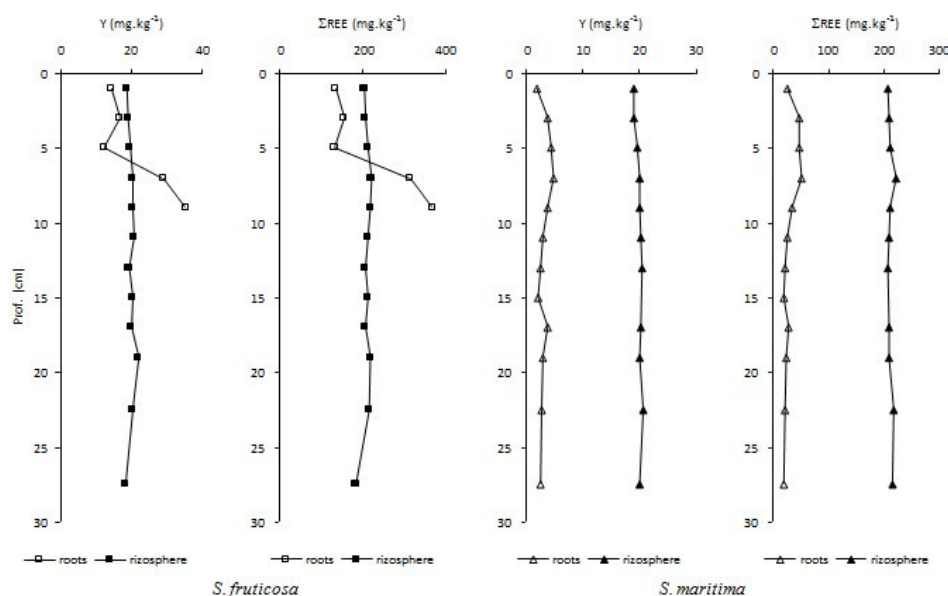


Fig. 2 Yttrium (Y) and total rare earth elements (Σ REE) contents (mg.kg⁻¹), in the roots of *S. fruticosa* and *S. maritima*, from Castro Marim salt marsh.

The (La/Yb)PAAS ratios were similar in the *S. fruticosa* (average value 1.8±0.16) and *S. maritima* roots (average value 1.8±0.39), compared to the rizosphere (average value 1.2±0.04). Higher ratios were found in stems and leaves from both species, with a larger enrichment of LREE relative to HREE. The average (La/Yb)PAAS ratios in the *S. fruticosa* were 2.2 for both stems and leaves, while for the *S. maritima*, the obtained values were 2.1 and 2.7, respectively.

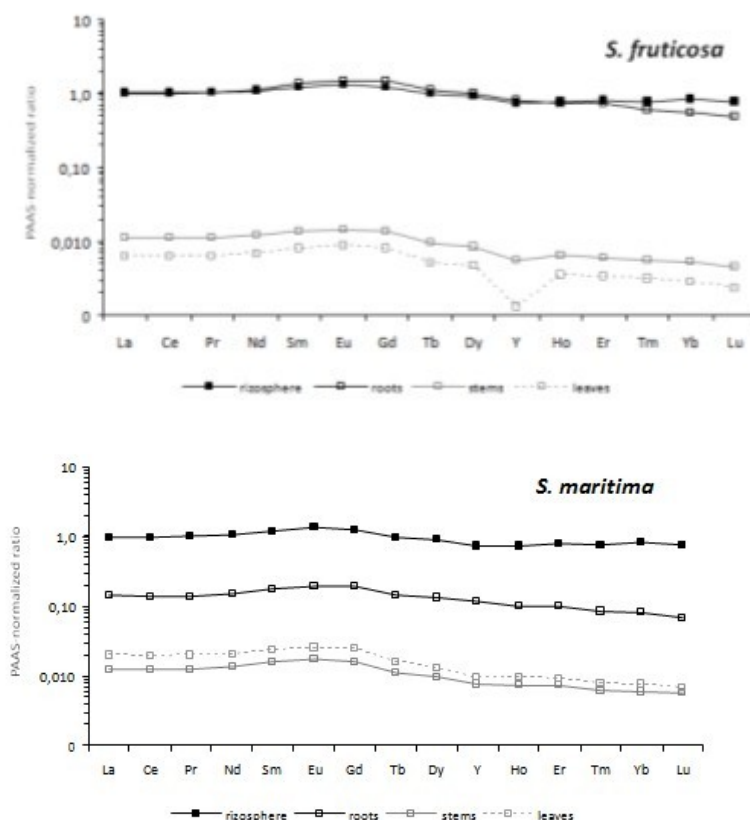


Fig. 3 PAAS-normalized fractionation patterns in the *S. fruticosa* and *S. maritima* roots, stems and leaves, compared to the rizosphere ratios, collected in the Castro Marim salt marsh.

CONCLUSIONS

This study showed that *S. fruticosa* and *S. maritima* exhibited different capabilities to extract YREE from the rhizosphere into the root system and to relocate from the roots to the aerial part of each plant. Interestingly the existence of preferential layers of YREE uptake/retention by roots of *S. fruticosa* seems to occur.

ACKNOWLEDGEMENTS

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B4 - Integrated constructed wetlands for mine-influenced water

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INTRODUCTION

Mine-influenced waters (MIW) pose a range of difficulties for “passive” treatment options currently available. Ranging from high metal concentrations, toxic pH ranges, Thiosulphates, hydraulic loading rates from capped tailings to long life-span requirements for operations.

VESI Environmental Ltd., based in Ireland has worked with Galmoy Mines in Co. Kilkenny in Ireland for the treatment of runoff from the final capped area from the Tailings Management Facility (TMF). The site was an underground Lead and Zinc mine which closed in 2013. VESI has worked with Lundin Mining since 2009 to examine the capacity of the Integrated Constructed Wetlands (ICW) concept (Scholz, et. al, 2007; Harrington & McInnes) for the effective treatment of runoff from the final cap.

A field-scale trial was run in 2009, which progressed to a full-scale design and construction project for the creation of a 7 hectare ICW for the total management of all runoff from the TMF cap. The ICW was put into operation as soon as it was planted with emergent vegetation. It was commissioned over a 12 month period before any surface water was discharged to the local surface water stream.

The success of the ICW at the Galmoy Mine, has been developed upon and the concept has been advanced through the use of a novel research platform designed for examining new and emerging contaminants (Harrington and Scholz, 2010). Originally based on research work on high-strength ammonia wastewaters, such as piggery manure, his Meso-scale ICW platform has been employed by other mining facilities in Ireland, Portugal and most recently Spain.

Utilising a robust and adaptable design, a research trial can be constructed for specific wastewater types, taking into account variability in flows, concentrations, native flora and site-specific characteristics, such as soils and hydrology. Currently, these meso-scale trials are being used for examining the removal of Sulphates with concentrations between 1,500 and 4,500 mg/l and pH values as low as 1.5.

RESULTS AND DISCUSSION

The meso-scale trials are currently in their early stages of operation and are showing varying performance/results under extremely harsh conditions. Initial performances for medium-strength (1,500mg/l) Sulphate influents were recording 50-60% reductions. High Sulphate and Thiosulphate waters have proven to be more problematic with removal of Sulphates being limited.

However, despite low removal rates in the high-strength waters, the adaptability of the emergent Helophyte species being used is remarkable, with *Typha latifolia* and

Phragmites australis being capable of grown successfully in waters with a pH as low at 1.5.

The table below provides the emission limit values set by the Environmental Protection Agency (EPA) discharge licence for the Galmoy Mine ICW.

Table 1. Emission limits vs performance for Galmoy Mine ICW

Control Parameter	Emission Limit value
Ph	6 – 9
Suspended Solids	<25mg/l
BOD	1.5mg/l
Total Ammonia (as N)	0.065mg/l
Ortho Phosphate (as P)	0.035mg/l
Sulphates	400mg/l
Arsenic	25ug/l
Mercury	0.05ug/l
Cadmium	2.5ug/l
Lead	7.2ug/l
Zinc	100ug/l

The full-scale ICW at Galmoy Mine, now in operation over 2 years (since October 2014) is showing consistency in the high removal of nutrients and metals of the through- flowing MIW from the rehabilitated capped TMF areas.

CONCLUSION

The ICW concept has proven to be a viable and well functioning approach to passive treatment of MIW from closed mines. Their low energy input and long life-span makes them a strong option for mining sites to consider for post-closure operations.

The implementation of the ICW concept at operational mining sites is still in early development and have varying degrees of success. Their continued development will provide greater insights into the bio- geo-chemical processes that can help to deal with MIW in situations where the only alternative are multi-million electro-mechanical systems.

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A7 - Assessing wetland status and trends: Issues, challenges and SWS initiatives

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Abstract

Whilst there has been some recent progress in assessing trends in wetland area change (i.e. loss: Davidson 2014; Dixon et al. 2016¹), it is just as important for decision-takers striving to achieve the sustainable management of their wetlands in the Ramsar Convention (and other processes such as the Convention on Biological Diversity's Aichi Targets) to understand what is happening to the state of their remaining wetlands, including designated Wetlands of International Importance (Ramsar Sites).

Yet current reporting to the Ramsar Convention on wetland status is limited, and there are many differing approaches to, and scopes of, assessing what is often termed “wetland status and trends”. Assessment results are scattered through the literature, presented differently and hard to compare.

The SWS Ramsar Section has, through symposia at the SWS 2016 and 2017 conferences and a workshop at the 10th INTECOL wetlands conference, been exploring how to improve wetland assessment information and reporting, and is developing a project to improve the availability of wetland status and trends information.

This presentation will outline the different aspects of the SWS Ramsar Section project, its preliminary results, and particularly its initiation of the ‘citizen science’ best expert opinion wetland status and trends questionnaire aspect of this project. SWS Europe Chapter conference participants will be urged to contribute to this assessment.

¹ Davidson, N.C. 2014. How much wetland has the world lost? Long-term and recent trends in global wetland area. *Marine and Freshwater Research* 65(10): 934-941; Dixon, M.J.R., Loh, J., Davidson, N.C., Beltrame, C., Freeman, R. & Walpole, M. 2016. Tracking global change in ecosystem area: The Wetland Extent Trends index. *Biological Conservation* 193: 27–35.

C1 - Sea level rise impacts on estuarine salt marshes - A multi-disciplinary approach

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One aspect that acquired a great meaning in the last years is the vulnerability of the coastal areas to SLR, especially salt marshes. Gathering a multidisciplinary approach from geochemistry, to hydrodynamics and ecophysiology, a holistic point of view on this problematic could be attained. Although salt marshes maintain positive sedimentation rates having the mean SLR as comparison, this might not be true in the future due to the increased anthropogenic pressures in the estuarine systems. Additional studies (Valentim et al., 2013) showed that SLR scenario could lead to changes in nutrients and sediments patterns around the salt marshes and thus vegetation coverage percentage would be affected. Additionally, as a consequence of flood duration increase, sediment moisture will increase causing a stress condition to plants. Hence, the ratio below/aboveground biomass might increase, becoming critical to plants survival under conditions of accelerated SLR. Accordingly, both SLR and expected changes in vegetation coverage percentage in controlling salt marshes evolution have important implications in their stability and consequently in coastal management. This was lately confirmed by the finding presented in this chapter.

Gathering a multidisciplinary approach from geochemistry, to hydrodynamics and ecophysiology a more holistic point of view on this problematic could be addressed. The pioneer *Spartina maritima* undergoes periods of stress when exposed to prolonged tidal submersion (Duarte et al., 2014a). Thus, this will have serious implications on its primary production, corroborating the hypothesis advanced by Valentim et al. (2013). This has serious implications not only on the ecosystems services provided on land by salt marsh halophytes but also for the entire estuarine system, as these are important areas with several functions for the whole ecosystem. Some examples of these functions are the contaminant remediative capacity of the salt marshes (Duarte et al., 2016) and its nutrient recycling role and food sources for secondary production (Duarte et al., 2014b). Due to the increasing stress conditions to which the halophytes are exposed under SLR, the senescence mechanisms will be more evident.

Results from these studies point out an increasing number of necromass particles exported to the oceanic waters adjacent to the estuarine areas, as a combined result of the increased senescence and altered hydrodynamical features. If by one side, this will increase the fueling of the secondary production of the coastal shelf by supplying higher amounts of particulate organic C and N (Duarte et al., 2014b), on the other hand will also contribute to an increasing contamination of these oceanic waters, due to a higher number of contaminated detritus that will not be retained within the estuarine remediative area. (Duarte et al., 2016). Thus, it becomes important to address SLR from a multidisciplinary approach, as these processes impacts on the halophyte vegetation

will condition the whole system at several and different levels. Being trapped between the sea and the urbanized lands, this data points out to a reduction of the salt marshes foundations (by reduction of its pioneer species) with enormous impacts on the coastal erosion, possible eutrophication events and reduced remediative capacity of the ecosystem, making it prone to a possible collapse.

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D6 - Effects of climate-driven invasion of mangroves on C and N cycling processes in salt marshes

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INTRODUCTION

Contemporary climate change is resulting in poleward expansion of mangroves as a result of moving thresholds of low-temperature frequency. Mangrove trees are moving into saltmarshes in regions where climatic gradients are reflected in spatial saltmarsh-mangrove transitions. As mangrove trees and saltmarsh plants are known to produce litter that is different in chemistry and decomposability, the mangrove invasions are expected to result in slower decomposition rates and possibly higher carbon sequestration. In addition, root exudates in the two systems are expected to affect the carbon and nitrogen cycling processes in the soil in different ways as well. Our study involved the planting of *Rhizophora mangle* seedlings and the transplant of leaf litter of this species into a *Distichlis spicata* saltmarsh along the east coast of Florida.

RESULTS AND DISCUSSION

The results indicate that *Distichlis* litter decomposition is slowed down by the presence of mangrove seedlings and/or litter. There was also a clear growth response of the mangrove seedlings, which produced larger numbers of leaves and branches in the plots with *Rhizophora* litter. Effects on nitrification, denitrification, plant N uptake and microbial community composition were much smaller than expected. There were effects of fluctuations in salinity resulting from rain events. In wet periods salinity in the marsh was low, which led to higher nitrification rates. There are strong indications that mangrove invasion in saltmarshes will lead to slower decomposition and higher carbon accumulation, while the nitrogen cycle remains relatively unaffected.

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E4 - Diversity of macrophytes in waterbodies conditioned by riverine water

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INTRODUCTION

In the areas where the natural flows of rivers have been changed, many different small size waterbodies like backwaters, side channels, oxbows, side arms and ponds can be found. These waterbodies hold great potential for the conservation of biological diversity, but they receive little recognition and no protection. Besides being a habitat for a variety of species, they may also positively affect water quality in the river. They are subjected to pronounced water level fluctuations that depend on precipitation rate and water level in the river. Due to small size they often dry out that affect biota, including the presence of truly aquatic species. In present study we examined macrophytes in different types of waterbodies, natural and man-modified, in the vicinity of rivers.

METHODS

The studied waterbodies are located along the rivers Drava and Mura (Slovenia). Macrophyte surveys were carried out examining transects in larger waterbodies (i.e. ponds) and the whole area of the smaller ones. We recorded truly aquatic species and helophytes separately. Plant species presence and abundance was estimated following the methodology proposed by Kohler and Janauer (1995). The environmental condition of waterbodies comprised land-use type beyond the riparian zone, characteristics of the riparian zone (width, completeness and vegetation type) and bank structure, each describing 4 levels of environmental gradient. Selected physical and chemical parameters were also measured.

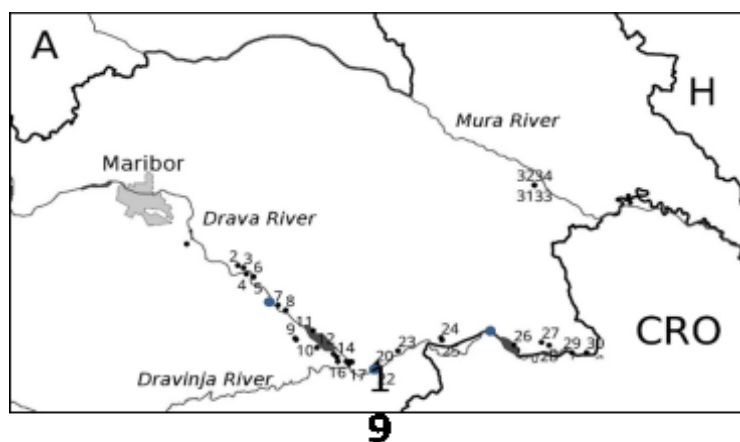


Fig. 1. Locations of surveyed water bodies. Grey circles present locations on the river.

Canonical correspondence analysis (CCA) was used to assess the relationship between plant species composition and abundance and environmental parameters or water quality parameters.

RESULTS and DISCUSSION

Altogether 89 macrophyte taxa, namely 47 helophytes and 42 hydrophytes were recorded in 34 waterbodies. The majority of waterbodies was surrounded by forest. The highest species diversity was detected in man modified ponds, where some plant species were also introduced. Helophytes were present in all examined locations while hydrophytes were absent in shaded shallow waterbodies. The comparison of these waterbodies with three locations on the river showed differences in species composition. Species variability was significantly affected by the type of riparian vegetation and electric conductivity of water.

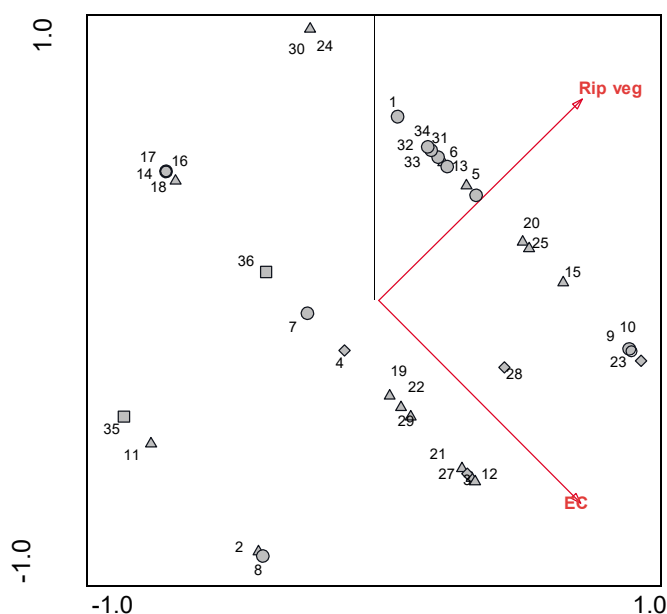


Fig. 2. CCA plot of different waterbodies with respect to riparian vegetation type (Rip veg) and electric conductivity of water (EC); circles –ponds, up-triangles –oxbows, diamonds-side channel, squares – river.

CONCLUSIONS

The results of the study reveal important contribution of surveyed waterbodies to biotic diversity of the area and provide data for their conservation and management.

ACKNOWLEDGEMENTS

The study was performed in the framework of the project LIVEDRAVA, LIFE 11 NAT/SI/882.

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A6 - The distribution of ponds in northern Poland: order and chaos

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INTRODUCTION

Ponds in northern Poland are mainly water bodies of natural origin. Their genesis is associated with the presence of an ice sheet during the most recent glaciation. Ponds are therefore present all over the area that was once covered by the ice sheet about 10,000 years ago. Although the exact number of ponds in Poland is unknown, it is estimated at up to 250,000 (Choiński 1999) with their densities in some locations being up to 80 per square kilometre (Golus, Bajkiewicz-Grabowska 2016).

METHODS

In order to establish the exact number of ponds on the territory of Gdansk Pomerania (the eastern part of Pomerania, ca. 12,300 km²) we used topographical 1:25,000 scale maps. We found that this area includes 30,880 ponds with a surface area of less than 50,000 m², which yields 2.5 water bodies per square kilometre. These are mostly small water bodies with a surface area of no more than 100 m² each.

RESULTS and DISCUSSION

Most (70%) ponds in the lake district landscape are scattered. Quite commonly, the ponds line up to form cascade systems, the so-called pond series. These are ponds found at the bottoms of longitudinal depressions of land and connected by permanent or periodic streams or separated by soaked-up or dry longitudinal depressions of land, which may be connected to form a single line. Series of ponds may merge to form cascade systems with lengths from several hundred metres to up to several kilometres, composed of up to several dozen water bodies, including small lakes, similar to river and lake systems in the micro scale. Their determination requires verification in the field.

Ponds in a lake district landscape quite often occur in clusters, taking up the bottom of a single depression of land. Such distribution is referred to as a cluster of ponds. A depression of land with a cluster of ponds has a flat bottom taken up by at least 3 ponds accompanied by bogs. The border of a cluster of ponds is determined by the first contour line above the bottom of the depression.

The sizes of the clusters of ponds range from several hundreds of square metres to a dozen or so of hectares. Clusters of ponds are commonly found in the entire area of Gdansk Pomerania we analysed. We identified 441 such clusters. They include a total of 2,522 ponds, i.e. 8.2% of all the ponds found in this part of Pomerania, and have a total area of 31.52 km².

The number of ponds making up a single cluster ranges from 3 to 65. The surface area of a single cluster of ponds ranges from 2,860 to 897,000 m². The average cluster is made up of 6 ponds and covers an area of 71,500 m².

CONCLUSIONS

Chaotically distributed ponds are water bodies that are mainly endorheic. The circulation of water in these types of water bodies is therefore determined by precipitation and evaporation and by the underground water exchange flux. The distribution of ponds in series may suggest that for at least some of the year the ponds may be included in the river network. The water circulation here is therefore determined by the river water exchange flux. Clusters of ponds most commonly form widespread boggy areas, which offer favourable conditions for pit species that are often endangered and protected. They also serve as natural reservoirs that store water. Therefore the distribution of ponds indicates their function in the circulation of water and the potential locations of rare and protected species.

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SWS PST 13 - The influence of extreme hydrological condition on phytoplankton community structure in protected sections of two lowland rivers

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INTRODUCTION

The structure of fluvial plankton is largely determined by both hydrological factors and water quality (Grabowska, et al. 2014; Bortolini et al., 2016). Most rivers were subjected to varying regulations which cause the decrease in biodiversity and increase in productive processes (Wetzel, 2001). Only a few large and medium European rivers preserved their natural character. The Biebrza River is an example of unregulated river while a large dam reservoir was built on the Narew River in 1990. The Narew River, located in NE Poland, is the largest (484 km) tributary of the Vistula River. Within the area of the Narew National Park (NNR), the Narew River converts its meandering riverbed into a unique anastomosing system. The Biebrza River is a medium-sized (165 km) low-gradient river, one of the larger tributaries of the Narew hydrographic network. In the middle section its natural landscape and flood-pulse pattern have been nearly entirely preserved. Excluding a 10-km-long section, the river is a part of the Biebrza National Park (BNP), and it is protected under the Ramsar convention. The aim of the research was to compare composition of phytoplankton in meandering sections of the Narew and Biebrza rivers in relation to variable hydrologic conditions.

METHODS

Water for phytoplankton analyses was sampled in June and September in the years 2009- 2013, from 2 stations of the Biebrza River, 10 oxbows and 2 stations of the Narew River. The most of stations were located within protected area BNP and NNP. Riverine stations were located in the mainstream of the meandering channels. In each oxbow sampling took place from a boat at 3 stations 3 (upstream arm, downstream arm and the middle section). Material for microscopic analyses was preserved by the addition of acidified Lugol's solution. Both a light microscope (Olympus BX50) and inverted microscope (Olympus CX41) were used for qualitative and quantitative analyses, respectively. Data concerning water levels and discharge in the rivers were provided by the Institute of Meteorology and Water Management - National Research Institute in Poland.

RESULT

and

DISCUSION

The study was carried out during a period of high variability of water levels and flows in both rivers. The highest discharges in case of the Biebrza River were recorded in 2013 and in case of the Narew River in 2010. In both rivers the lowest biomass of

phytoplankton (PB) corresponded to the highest flow that was recorded during the study period. Phytoplankton biomass in the meandering section of the Narew River reached higher values than in the Biebrza River (Table 1). The highest PB in the Narew River (27.41 mg L⁻¹) were noted in September 2009 during the period of the lowest flows. Phytoplankton was composed mainly of planktonic species from the hypertrophic Siemianówka dam reservoir located on upper course of the Narew River. The dominant was toxic *Planktothrix agardhii* (Cyanobacteria).

Only during the highest flow period (June 2010) a small dominance over Cyanobacteria showed Cryptophyta, a species more representative for potamoplankton. Significantly higher decrease in cyanobacteria biomass was recorded at the station 2 at a greater distance from the hypertrophic reservoir.

Table 1. Comparison of total phytoplankton biomass and discharge in Narew and Biebrza rivers

Station	Biomass of phytoplankton		Flow m ³ s ⁻¹	
	mg L ⁻¹			
	Range	average	range	average
Biebrza River (BR)	0.079–4.490	0.612	7.08–88.5	27.4
Eupotamon oxbows of BR	0.047–5.497	0.611		
Parapotamon oxbows of BR	0.084–4.622	1.123		
Plesiopotamon oxbows of BR	0.108–4.276	1.202		
Narew River (NR)	0.200–27.41	5.983	4.95–33.3	14.9

The potamoplankton of the Biebrza River was dominated mainly by diatoms (Figure 1). Chlorophytes and dinophytes reached about 10–20 % of the PB. Community structure of phytoplankton in the Biebrza was typical to phytoplankton found in unregulated lowland rivers. Genuine riverine phytoplankton is mainly dominated by diatoms, green algae and/or cryptophytes due to water turbulence. In eupotamon oxbows community structure of phytoplankton was the most similar to the Biebrza phytoplankton. In oxbows of parapotamon and plesiopotamon types a distinct increase in Dinophyta, Cryptophyta, and Chrysophyceae was recorded in the PB. High water levels promoted exchange among waterbodies and the Biebrza floodplain. We assumed that hydrological conditions cause significant variations in phytoplankton parameters. Our results showed that unregulated Biebrza River and its oxbows are characterized by more variable species composition of phytoplankton when compared to the dammed section of the Narew River.

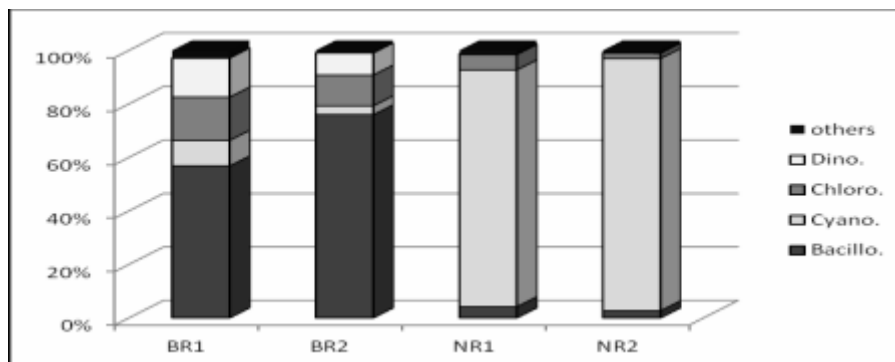


Fig. 1. Comparison of the phytoplankton community structure in the Biebrza River (BR) and the Narew River (NR); Bacillo.- Bacillariophyceae, Cyano.- Cyanobacteria, Chloro.- Chlorophyceae; Dino.- Dinophyta; average values of the study period

CONCLUSIONS

Our results confirmed that unstable hydrological conditions which took place in June- September 2009–2013 are decisive in terms of effects on the structure of phytoplankton communities. In both rivers the highest flows foster the decrease the total biomass of phytoplankton. However, in the Biebrza River diatoms were permanent dominants while in the Narew River cyanobacteria ones. It was observed that higher flows in the dammed Narew River had positive effects on the ecological status of the river. The changes were induced by faster dilution of reservoir phytoplankton in the downstream river section. As a consequence, a faster decrease in PB and in cyanobacteria biomass in the river were observed. Among oxbows the highest PB was noted in lakes of the plesiopotamic type.

ACKNOWLEDGEMENTS

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A1 - Wetlands status and trends in the Mediterranean region

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INTRODUCTION

Extensive wetland destruction has been reported globally as extensive and almost four times more rapid during the 20th century than in previous centuries (Davidson 2014) and continuing, with a 30% area loss between 1970 and 2008 reported by Dixon et al. (2016). It is also reported that many remaining wetlands are in a degraded state and/or are deteriorating in state. However, this information on such deterioration is most often widely scattered through the literature and information on the state, and change in state, of wetlands is not readily accessible worldwide to decision-makers, although some recent local/ regional improvements exist. The decline of natural and semi-natural wetlands and their artificialisation continue, in the north as well as the south of the Mediterranean Basin affecting the biodiversity and more generally the functions and services provided by these ecosystems. At the interface of diverse interests and options for land- use, political decisions are more often in favour of the activities that impact wetlands (agriculture, urbanization, and the development of infrastructure, water abstraction) than for their conservation. The Mediterranean Wetland Observatory, launched in 2008 under the aegis of the Mediterranean wetland Initiative (MedWet), is a wetland management tool intended to serve the 27 MedWet initiative countries. The ultimate objective of the Mediterranean Wetland Observatory is to contribute to better protection and management of Mediterranean wetlands (defined as the wetlands in the 27 countries of the MedWet initiative). It has two operational objectives: (1) To analyse the status and trends of Mediterranean wetlands, including their biodiversity, the goods and services that they deliver and the environmental factors and anthropogenic pressures that explain their status and trends; and (2) To promote effective decision-making for the protection, restoration, wise use and sustainable management of Mediterranean wetlands.

METHODS

With its partners, which include BirdLife International, Wetlands International, IUCN, WWF- MedPO, MedWet, Plan Bleu and Ramsar, the MWO has identified a series of themes and a parsimonious set of 25 indicators for Mediterranean wetlands, based on a DPSIR model (Figure 1) among which in 2012 17 of these 25 indicators were developed (MWO 2012a). Indicators on wetland loss (1975-2005) and land-use were calculated by remote sensing analyses (Landsat) on a sample of 214 coastal-wetland sites disseminated throughout the Mediterranean basin, Biodiversity indicators were calculated using a database centralizing time series of vertebrate populations and by calculating a Living Mediterranean wetland Index, derived from the Living Planet

Index (Loh et al. 2005) and Temperature Community Index (Devictor et al. 2008). Differences in the Living Mediterranean Index were tested between 2 sub-regions (West and East). On other themes, indicators were collected from literature reviews (e.g. water, ecosystem services).

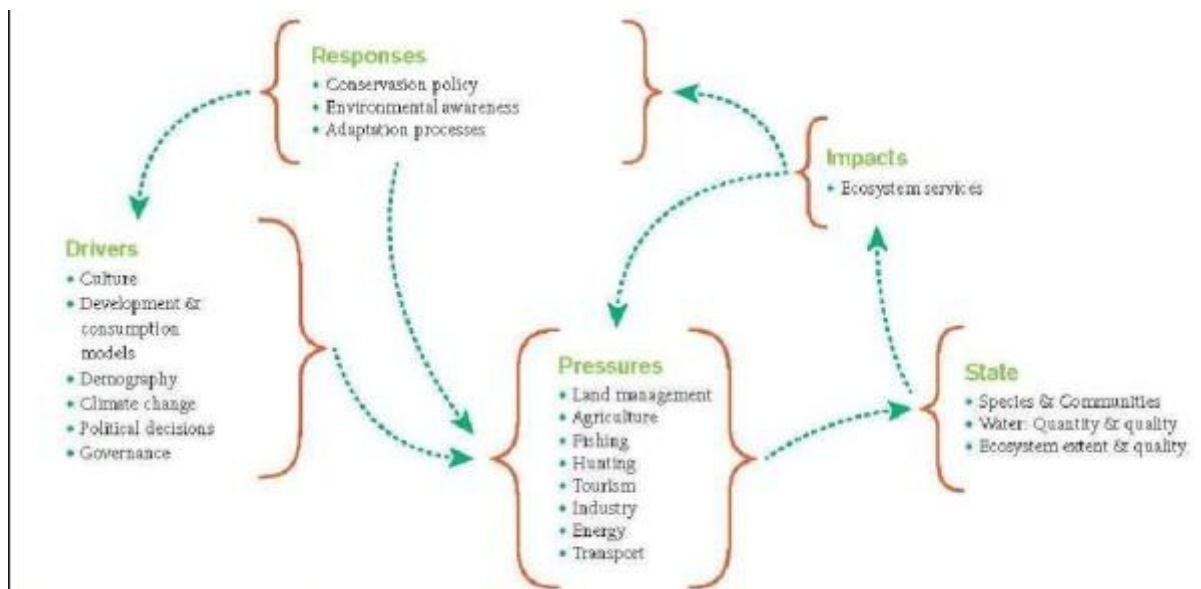


Fig. 1. MWO conceptual framework (in the form of a DPSIR model: Forces, Pressures, Status, Impact, and Responses).

RESULTS AND DISCUSSION

Wetland loss and land use

Data on wetland surface areas in the Mediterranean region is heterogeneous and scattered. By year 2000, existing evidence supports and estimate total surface area of c. 15-22 million ha in the Mediterranean countries, i.e. 1.5% of the world's wetlands (Perennou et al. 2012). About 23% of existing wetlands by 2000 were man-made (e.g. ricefields, salt pans, reservoirs).

Wetland loss history and extent differs widely between sub-regions of the Mediterranean basin along with economic development. In recent years (1975-2005) at least 10% of natural wetland habitats were lost (-1300 km²) in the Mediterranean region. During the same period, the surface area of artificial wetland habitats increased by 102% (+855km²). The rate of wetland loss in recent years appears lower than globally, i.e. 30% (Davidson 2014, Dixon et al. 2016), maybe because of the earlier destruction in this part of the world, and because various sources of under-estimation exist in the Mediterranean method (MWO 2014).

With about 71% of lost wetland area converted to agricultural land, agriculture appears as a major driver of wetland loss. However, transformation to artificial wetland habitats (aquaculture, reservoirs, 21%) had also a significant contribution to wetland loss. With only 8% direct contribution to wetland loss, urbanization, which encroached on agricultural land, had probably an additional indirect impact on wetlands, fostering agricultural shift on them. The fast increasing population in the Mediterranean Basin combined with the concentration of populations in urban areas along the coast ("littoralisation" process) (Plan Bleu 2005) is probably a major driver of wetland loss.

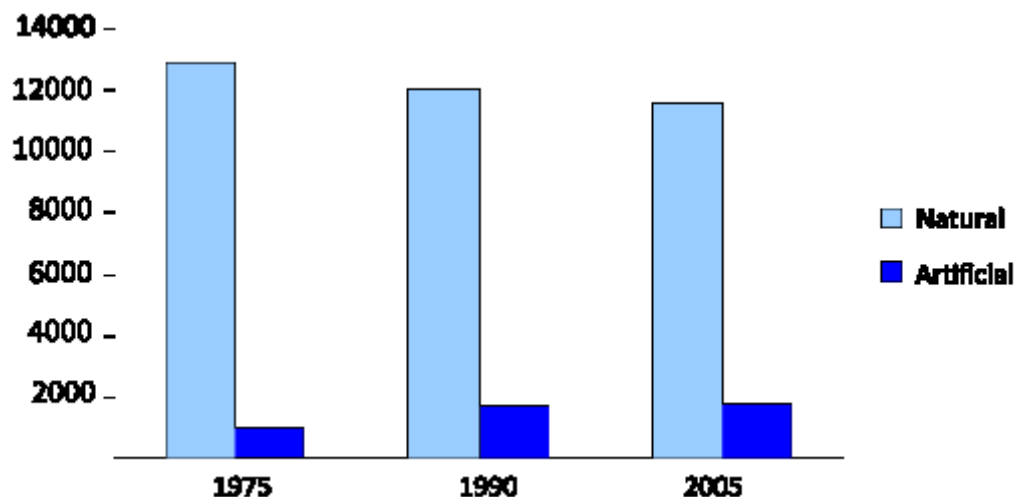


Fig. 2. Changes in the surface area (km²) of natural and artificial wetland habitats identified on a sample of 214 wetlands in the Mediterranean basin. (after Beltrame et al. 2015)

Biodiversity

The Living Mediterranean Index (1970-2009) showed a flat trend which contrasts with the strongly declining Living Planet Index. However, when trends are analyzed by vertebrate groups, a clear difference appears between waterbirds which showed a strong increase (+70%) in the study period, and all other groups of vertebrates (fish, amphibians, reptiles and mammals (-40%). Similarly, trends were contrasted between West- (increase) and East-Mediterranean countries. It is important to notice however that the data available were scarce and strongly biased towards west-Mediterranean countries and waterbirds. High proportion of assessed species inhabiting Mediterranean wetlands are listed as Globally Threatened (IUCN RedList), including Molluscs: 48%, Plants: 33%; Fish: 31 and Amphibians 24%. (MWO 2012b). According to IUCN Red Lists, the conservation status of amphibians, freshwater fishes, mollusks and plants is really unfavorable with one-third to half of species threatened with extinction at the global scale. These endangered species are often endemic to water courses or temporary-flooded wetlands which are barely visited by biologists and their population trends are poorly known. Improving the spatial and taxonomic representativeness of data is needed for a better understanding of the present situation and past trends.

A positive message is that the conservation measures for some species and notably colonial water birds (E.U. Bird Directive, Bern Convention) as well as the Ramsar convention and the Habitat Directive of the E.U. have probably a positive impact on some highly visible species (EEA, 2010). The increasing trend of these populations is probably also fostered by the numerous and abundant fish and crayfish species which have been introduced and thrive in the Mediterranean Basin providing abundant food resources of some species (Poulin et al. 2007).

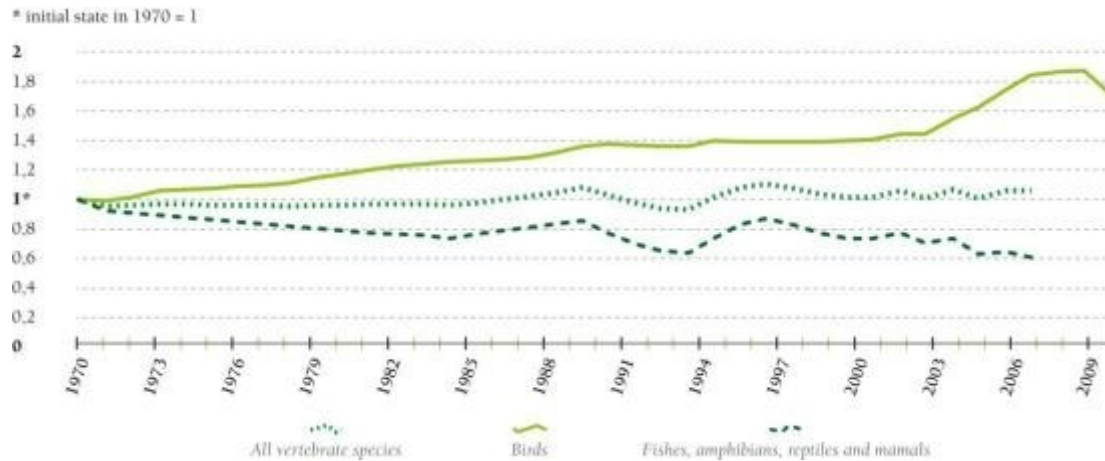


Fig. 3. The Living Mediterranean Wetland Index for vertebrates (middle dotted line), waterbirds (solid line) and other vertebrates (fish, amphibians, reptiles and mammals, lower dashed line).

Water resources

There is plenty but scattered and heterogeneous information (quantity and quality) of water resources in Mediterranean wetlands. This information provides a picture of the pressure that exists on water resource sin the Basin. In the XXth century, the discharge of most rivers (except the Rhône River) declined sharply and the freshwater flow to the Mediterranean Sea has been reduced by circa 45% in less than a century (Ludwig et al. 2013). Several factors can explain this trend among which the fast increase of water diversion and storage in dams for human uses. Between 1950 and 2000, the storage capacity of dams has increased 10folds in the Mediterranean countries (Margat & Treyer 2004). Agriculture is the main user of water with 66% of the demand (84% in North-African countries) (Plan Bleu 2009). Overall Mediterranean countries use (exploitation index) circa 25% of their renewable resources but large differences between countries, several being beyond safety thresholds notably in the SE sub-region (Figure 3; Plan Bleu 2005). The increasing size of the population, the need for development and climate change will increase the pressure on water resources and further threaten wetlands and their services to the people.

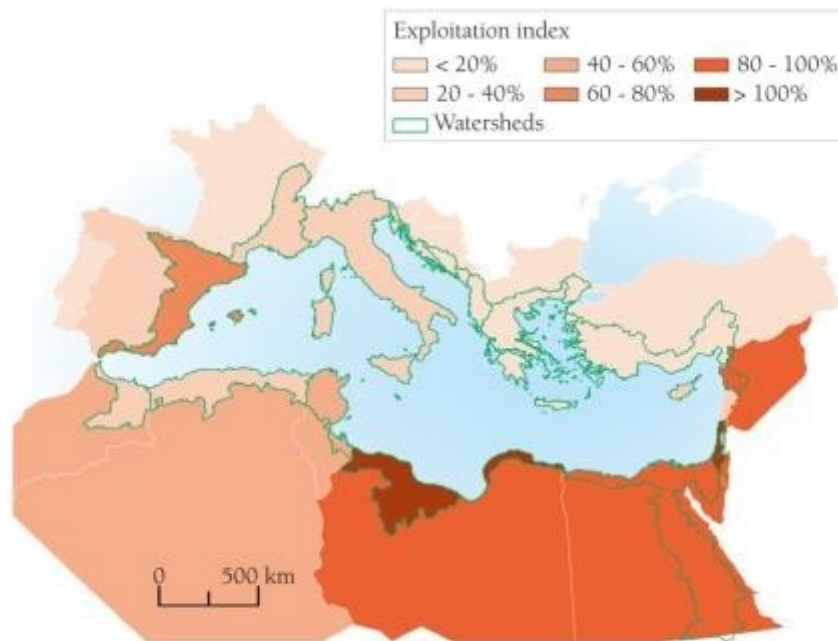


Fig. 3. Exploitation index of renewable water resources in Mediterranean countries (From Plan Bleu 2005).

Policy responses

Conservation measures have been implemented at the national and international levels. The Ramsar convention (1971), the first international convention on biodiversity is dedicated to the conservation of wetlands and signed by all Mediterranean countries. The surface area of Ramsar sites (covering not only wetlands however) has strongly increased in the Mediterranean Basin (Figure 4). The impact of the Ramsar convention on the conservation of wetlands is considered as relatively positive (Davidson et al. in prep.) but remains under expectations and differ most probably between countries. The positive effects of Ramsar sites could be reduced for large sites (Davidson et al. in prep) and preliminary results suggests that it is enhanced when a management plan exists (Korichi & Treilhes, 2013). The Bern Convention (1979) for nature conservancy and for the E.U. directives, the Habitat Directive (1992 Directive 92/43/EEC); Birds Directive (2009, Directive 2009/147/EC) are important conservation measures with a strong impact of policies in E.U. and accessing countries. These directives play probably an important role on the positive trends of some listed species and habitats. About one third made integrated strategic efforts for wetland protection, combining wetlands inter-sector committee, wetlands national strategy or action plans, and updated legal framework. Amongst developing countries, 75% of them achieved significant results towards Millennium Development Goals environmental targets related to water and wetlands.

CONCLUSIONS

The Mediterranean Wetland Observatory has gathered and disseminated over the last nine years synthetic information on the status and trends of Mediterranean wetlands. More work is needed to improve the quality of the information and to transfer this information in recommendations for a sustainable management of Mediterranean wetlands. Trends show a strong pressure on wetlands with a loss rate however 3 times below global level (Davidson 2014, Dixon et al. 2016). The perspectives for water

abstraction (both surface and groundwater) are alarming and the role of wetlands in the water cycle and in providing clean water should be highlighted. More generally ecosystem services provided by wetlands remain underestimated and under-divulged although they should be part of the solution for adapting to global change.

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B1 - Adaptation of water framework indicators (phytoplankton and nutrients) for oligohaline and mesohaline Mediterranean lagoons

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INTRODUCTION

In the context of the Water Framework Directive (WFD) a single set of indicators has been established and consolidated at the E.U. level for Mediterranean coastal lagoons. These lagoons cover a wide range of salinity conditions with various and often high human pressure. Following these indicators oligo- and mesohaline lagoons are systematically found in Bad conditions. The 0.5-18 (oligo- [0.5-5] and mesohaline [5-18]) salinity range corresponds to a transition between fresh and marine waters with important consequences on the organization of all compartments of ecosystems and the salinity 5-8 has previously been identified as a critical range. Compare to marine and euhaline oligotrophic waters, at low salinity, nutrients concentrations should be higher, turbidity can be higher because of resuspension of sediments (de-flocculation of colloids) limiting light penetration into the water, is more abundant and few macrophyte species tolerate salinity fluctuations in this range.

METHODS

The physic-chemical parameters of nine oligo- and mesohaline lagoons were collected in summer (June, July and August) for the monitoring of water masses between 2003 and 2013. The number of years and stations sampled differed widely between lagoons (ranging from 3 to 38 years X stations). For each of 6 lagoon data were aggregated over time for 5 to 6 years and geometric means and percentile90 values calculated for each period. The 3 other lagoons were sampled only one year (2013).

The relationships between Ntotal and Ptotal were studied by linear regressions and compared with ratios for a broad range of salinity (Souchu et al. 2010). The classification of the ecological status for phytoplankton (biomass and composition) in lagoons is calculated by the ratio between observed values and reference lagoons (Ecological Quality Ratio, EQR). As no reference existed for oligo- and mesohaline water, the reference value for Chlorophyll-a was calculated as intermediate between reference values for freshwater lakes and for euhaline lagoons weighted by the dilution level. Reference values for the density of pico and nanophytoplakton were not modified from euhaline lagoon because no reference value exists for freshwater lakes. Relationships between nutrients concentrations and EQR Phytoplankton and Chlorophyll-a biomass were studied using linear regressions. The strongest correlations

were obtained with EQR phytoplankton. Using the prediction function of regressions (Statistica), the concentration of P_{total} and N_{total} were calculated corresponding to the EQR thresholds. These values are proposed as thresholds for corresponding to assessing the ecological status of oligo- and mesohaline lagoons.

RESULTS AND DISCUSSION

The concentration ratio N_{total}/P_{total} was higher for low salinity lagoons than found in the general model for lagoons but tended to convergence at higher salinity towards the same ratio (N_{total}/P_{total}= 16) (Figure 1). This result show higher relative concentrations of total nitrogen at low salinity. The concentrations of total phosphorus and total nitrogen in oligo- and mesohaline lagoons remained always above the lower values found in more saline lagoons (respectively above 60 µmoles.l⁻¹ N_{total} and 2 µmoles.l⁻¹ P_{total}, i.e. the box on Figure 1).

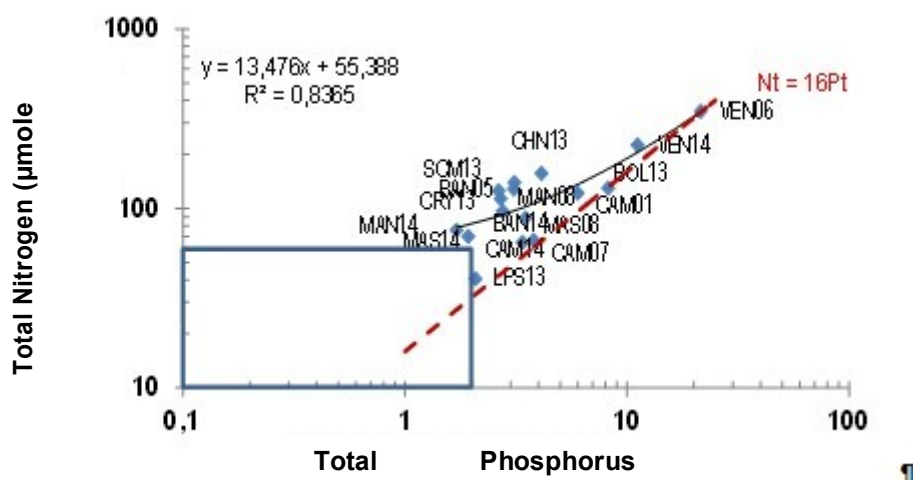


Fig. 1. Relationships between concentrations of Total Nitrogen and Total Phosphorus in oligo and mesohaline lagoons. The red dotted line corresponds to the Redfield ratio: N_{total}= 16P_{total} plotted for a wide range of lagoons in France (Souchu *et al.* 2010) ; the box at the bottom identifies the range of concentrations which is found in saline lagoons but not in oligo-mesohaline lagoons.

The biomass of phytoplankton (log Chlo-a) in oligo-and meso haline lagoons showed a significant linear correlation with the concentration of total Nitrogen (log of the percentile 90) (Figure 2a). This correlation is very close to the Redfield ration generally found in lagoons (Souchu *et al.* 2010, the red dotted line on figure 2a). Similarly the biomass of phytoplankton was significantly correlated to the concentration of total Phosphorus (log of the percentile 90) (Figure 2b) and the correlation is close to that found in general in lagoons (Souchu *et al.* 2010, the red dotted line on figure 2b).

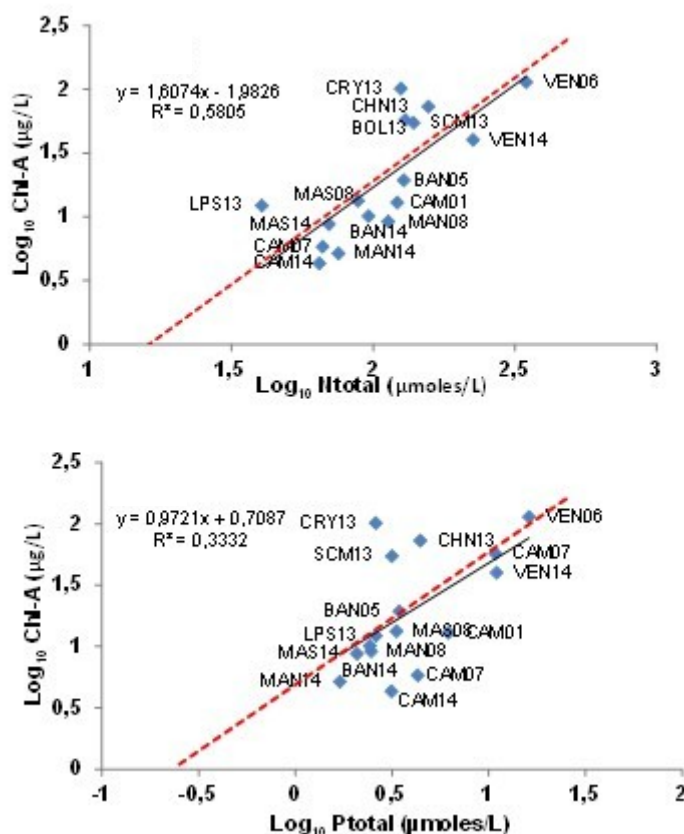


Fig. 2. Relationships between Chlorophyll-a biomass and the concentration of (a) Total Nitrogen and (b) Total Phosphorus ; the red dotted lines on both graphs correspond to the regression line found in Souchu *et al.* 2010.

The reference value calculated for the biomass of chlorophyll is 6.00µg.L⁻¹ (Table 1). This is almost the double of the reference for eu- and polyhaline lagoons (3.33µg.L⁻¹) but this value is similar to thresholds established in the oligo- and mesohaline parts of the Chesapeake Bay (Williams *et al.* 2010) and is consistent with the increasing nutrient concentrations with increasing inputs of freshwater. The reference values for the abundance of pico and nano- phytoplankton were not modified as no reference value exists for freshwaters. Ecological Quality Ratio thresholds for phytoplankton (EQRPHY) have been calculated using this new reference value for phytoplankton (Table 1).

Table 1. Grid of values proposed for the assessment of the quality of phytoplankton in oligo-mesohaline lagoons

oligo-mesohaline lagoons	Very Good	Good	Medium	Poor	Bad	Reference
Abundance (nb cell./L(X 106))						
picophyto	20	50	100	500	15	
nanophyto	4	10	20	100	3	
Biomass (µg.L ⁻¹)	9	15	27	51	6.00	
	Very	Good	Medium	Poor	Bad	

		Good			m					
EQRA abundance	Picophyto		0.75		0.3		0.15		0.03	
	Nanophyto		0.75		0.3		0.15		0.03	
EQRB biomass			0.67		0.40		0.22		0.12	
EQRPHY			0.71		0.35		0.19		0.07	

The correlation between nutrient concentrations and EQRPHY values were better than with the biomass of phytoplankton and were thus used to calculate thresholds quality values for Total Nitrogen (Figure 3) and Total Phosphorus (Figure 4). The weak correlations with dissolved forms of nutrients did not allow calculating quality threshold values for oligo- and mesohaline lagoons for the WFD. The thresholds for quality status of oligo- and mesohaline lagoons are as expected higher than those used in eu- and polyhaline lagoons (Table 2). The difference is in the range 15-29% (mean 23%) for Total Nitrogen and 12-25% (mean 18%) for total Phosphorus except for the threshold between “Poor” and “Bad” where it is circa 0% for both total phosphorus and total nitrogen (Table 2).

Table 2. Comparison of the threshold values for Total Nitrogen and Total Phosphorus in eu- polyhaline and calculated for oligo-mesohaline lagoons.

Total Nitrogen (P90)		Very good		Good		Medium		Poor		Bad
eu-polyhalines	μmoles.L ⁻¹		50		75		100		120	
oligo-mesohalines (calculated values)	μmoles.L ⁻¹		72		93		116		168	
oligo-mesohalines (thresholds proposed)	μmoles.L ⁻¹		70		95		115		170	
Total Phosphorus (P90)		Very good		Good		Medium		Poor		Bad
eu-polyhalines	μmoles.L ⁻¹		2		3		4		5	
oligo-mesohalines (calculated values)	μmoles.L ⁻¹		2,6		3,5		4,5		6,8	
oligo-mesohalines (thresholds proposed)	μmoles.L ⁻¹		2,5		3,5		4,5		7	

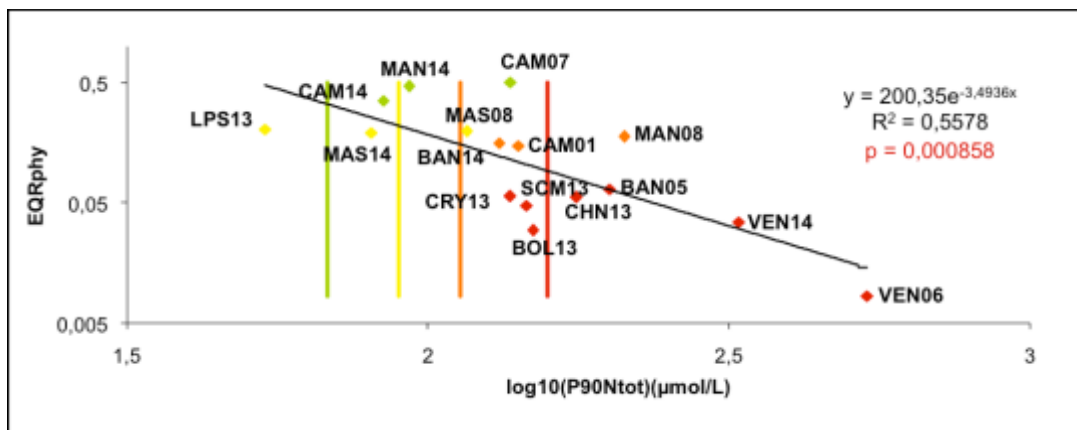


Fig. 3. Relationship between EQRphytoplankton and Total Nitrogen (log of the percentile 90) ($\mu\text{Mole.l}^{-1}$) ($\log(\text{P90-Ntot})$) and the threshold quality values calculated for Nitrogen ; color lines : Green : Very Good – Good threshold, Yellow : Good – Medium threshold ; Orange: Medium – Poor threshold; and Red : Poor – Bad threshold

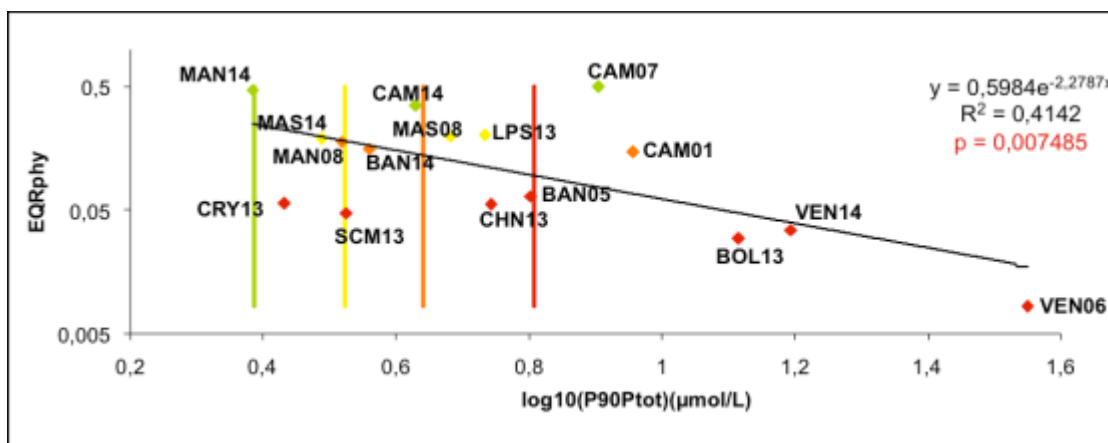


Fig. 4. Relationship between EQRphytoplankton and Total Phosphorus (log of the percentile 90) ($\mu\text{Mole.l}^{-1}$) ($\log(\text{P90-Ptot})$) and the threshold quality values calculated for Phosphorus ; color lines : Green : Very Good – Good threshold, Yellow : Good – Medium threshold ; Orange: Medium – Poor threshold; and Red : Poor – Bad threshold

Using the thresholds values developed for oligo- and mesohaline lagoons improved the classification of some stations (Table 3). The quality has been improved on 8/16 stations for the criteria phytoplankton, total phosphorus and total nitrogen and among these reached the Good quality status 3 stations for phytoplankton, (previously “3 Medium”), 5 for total phosphorus (previously 2 Good) and 4 for total nitrogen (previously 1 Good).

CONCLUSIONS

In coastal lagoons water from freshwater catchment and from the sea are mixed in various proportions. The nutrient content of freshwater and sea water differs widely (Sterner et al. 2008), the Mediterranean Sea water being oligotrophic (Estrada 1996) while freshwater receive nutrients from their catchment. Eutrophication resulting from human activities adds up to the naturally higher concentrations of nutrients in freshwater. Using the same criteria for a wide range of salinity resulted in imposing very strict criteria to lagoons where freshwater influence predominates.

The salinity range 0,5-18 (oligo- [0,5-5] et mesohaline [5-18]) corresponds to a transition in the organization of brackish water ecosystems, the range 5-8 having been identified as critical (Khlebovich 1968, Kinne 1971) characterized by a minimum species richness for large and benthic organisms and a maximum species richness for small and planktonic organisms (Telesh 2013).

The adaptation of quality thresholds for oligo-mesohaline lagoons is consistent with the mix of fresh and sea waters and show intermediate values between thresholds used in the water masses. In addition to higher nutrient concentrations oligo-mesohaline lagoons range makes difficult the identification of additional stress resulting from eutrophication (Elliott & Quintino 2007). This adaptation resulted in an improvement of the quality class for some stations but most lagoons remain classified in “Bad” quality for water and phytoplankton.

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D2 - Challenges encountered in reanimating wetlands – Reflecting on 30 years of effort

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INTRODUCTION

Efforts in wetland reanimation conducted over three decades for a wide range of purposes, continue to encounter resistance. Clearly, logical arguments expounding factual benefits of such efforts, no matter how well formulated often do not achieve cognisance. Primeval wetlands and forests, once the two natural biotopes dominant in Ireland and indeed across most of Europe, have both been greatly reduced, in fact virtually eliminated, over time. These losses, although redeemed in some measure where forestry and woodland are concerned, have resulted in widespread minimal awareness of the benefits and essential ecosystem services of wetlands - notwithstanding partial acceptance of the latter's beneficial contributions to the wellbeing of society.

A series of case studies in the reanimation of several wetland endeavours make this point. They cover projects first started in 1984 up to the present time. In each case specific objectives associated with various land-water management projects are discussed, along with pertinent social, economic and environmental factors. Conclusions identify factors limiting their deployment and how such limitations may be better addressed.

OBJECTIVE

Generally accepted strategies of intercepting, retaining and treating water sources are largely motivated by national and EU regulatory demands and requirements for innovation, including wetland reanimation and flood attenuation areas. These include meeting a range of site-specific hydrological functional demands, often subject to civil engineering considerations. Moreover, the social, economic and environmental aspects associated with additional benefits accruing from primary objectives, are not often appropriately envisaged, resulting in yet more 'hard' formulaic engineering approaches. As they are rarely explicitly taken into account during the design phase, initiatives delivering more optimal outcomes are often missed. Notwithstanding cost-benefits associated with most wetland construction initiatives, the accompanying ecosystem services as first outlined by Harrington and McInnes (2009) are rarely seen as key elements in the design making process. Initially the main focus associated with construction of a wetland is on economic cost-benefits. The intended work is often not viewed in the context of wider social, economic and environmental factors. The relationships between the beneficiaries and a long-term enterprise, particularly regarding management of water in the wider landscape, has been understood only gradually through demonstration. Analysis of such factors has improved means to advance their application.

METHODS

Analysis of completed projects over time has suggested several ways to better appreciate reanimating wetlands. These are enshrined in the ‘Integrated Constructed Wetland’ (ICW) concept which evolved from the earliest work, where 1.) all salient aspects of water management are explicitly incorporated into 2.) the landscape and the 3.) associated biodiversity potential realised. Verifying these three key elements has proven important:

1. The system must meet requirements regarding water quality effluent and hydraulic integrity.
2. The system must be accessible for maintenance and people.
3. Actions must be comprehensively and logically linked with objectives.
4. Land/capital, ancillary resources, alliances (collaborations) and related interests - often seen as competitive - must be assessed holistically.
5. The defined 12 principles and rational of the UNEP/CBD’s ‘Ecosystem Approach’ must be implemented right from the start.
6. The approach to each undertaking must be a site-tailored avoiding a formulaic approach.
7. Complex ‘open’ biological systems are typically subject to limitations of understanding and must be comprehended as such.

RESULTS

Today reanimating wetlands continues to be a marginal exercise when compared with most water management methodologies. Nonetheless, when conceptually based on the Integrated Constructed Wetland (ICW) concept and applying the above seven key elements they are then better accepted and seen as more economically competitive, with the public more appreciative of the natural and aesthetic landscape they provide.

CONCLUSIONS

Reanimating lost hydrological ecologies and ecosystem services within catchments for a multitude of purposes requires the collaboration of landowners, experienced direction and planning, as well as State engagement. *Innovative demonstration of what can be done is the initial priming factor provided requirements regarding water quality and hydraulic integrity are achieved.* Secondly, secure and effective water-retentive structures can be built cost effectively using local soil material with minimal hard construction and embedded carbon whilst providing a basis for enhanced aesthetics and biodiversity. As complex ‘open’ biological systems they can typically be subjected to limitations of understanding and ‘systems blindness’, especially where competitive interests may prevail.

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C5 - From wastelands to the Land of Fortune: Perceptions and consistencies about wetlands in Uganda

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INTRODUCTION

Uganda is a country with one of the highest population growth rates in Africa (3%) (UBOS 2014). Urbanization and the pursuit to a modern *Western* life style is present everywhere. Under these conditions, nature, and especially wetlands of Uganda are extremely under pressure and threatened. Even though, laws already exist the protection of wetlands is getting more and more difficult. Why are wetlands so attractive for residents and what has changed in the residents' perception about these ecosystems?

METHODS

In a wetland in Wakiso district, 50 km north of the capital Kampala, a mixed-method approach was applied. Six group interviews were conducted as well as a survey with 235 residents of the wetland. The studies provided knowledge about how residents in place perceive the wetland and in how far the wetland plays a role in their day-by-day life. The quantitative data were analysed by correlation and dependence analyses, while the results of group interviews were visualized by excerpting key information. On basis of the results of both studies, seven interviews with key informants were carried out and analysed.

RESULTS and DISCUSSION

All key informants, mainly chairpersons of local councils, stated that, in ten years, the wetland would not be existent anymore. They assigned this development to the tremendous increase of population and the common in heritage matters.

The demand of land increases and the *expanse of land* in the wetlands can supply these demands. Landowners and tenants are acting separated from law according to traditional conventions.

The wetlands provide attractive resources, since they contain water and land, which makes them convenient even for foreigners as source of income. The wetlands are perceived as *no-men's-land*, thus also foreign investors come to the wetlands to start business. It is now attractive to claim for a plot in a wetland.

The perception and emotional bonding to the wetland is more heterogeneous as it was before. While residents may perceive the wetland as source of livelihood and feel deeply committed to it (Shamai 1991), foreign investors only see the wetland as a short-term source of income. These developments contain a high risk potential in terms of land conflicts. The wetland helps to resist water scarcity during the dry season. However, farmers live in the continuous threat of being convicted by foreign investors or the government by enforcing and implementing laws. They do not have the security to plan for their short-term and long-term future, which influences their psychological well-being.

Furthermore, the wetlands' encroachment threatens natural environments and converts the wetlands to "dryland". The conversion results in a loss of ecological uniqueness. While elder persons feel solastalgia (Albrecht et al. 2007) about the loss of important places, Young people do not even know about the original flora and fauna. Locals tend to lose a part of their ecological identity (Kumar and Kumar 2008). They are in a precarious situation affecting their long-term well-being and livelihood.

CONCLUSIONS

Beside law enforcement, environmental protection requires a transdisciplinary collaboration and an improvement of the coordination of all sorts of stakeholders, which implies the inclusion of the local population. Local people are willing to protect the wetland, but they do not know how to realize. Especially in Uganda, wetlands can only be protected if the implementation of laws goes hand in hand with activities concerning family planning, alternative income strategies and the improvement of farming techniques. Furthermore, an adequate infrastructure containing streets and access to markets is required. In terms of emerging land conflicts, neutral consultants about mediation as well as investment strategies are needed.

On top of this, education about the uniqueness of wetlands and their flora and fauna as well as about their sustainable use is needed from NGOs and local engagements. The senses of wetlands need to be highlighted and young people ecologically sensitized. At the end, the protection of the wetland is a trade-off between different interests of different stakeholders, ecologists and politicians.

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D1 - Plant species used in floating treatments wetlands: A decade of experiments in North Italy

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INTRODUCTION

Floating treatments wetlands (FTWs) are innovative variants of traditional constructed wetlands, which involve rooted, emergent macrophyte plant species growing in hydroponic conditions on floating mats as supports (Headley and Tanner, 2006). The most commonly used macrophyte species for these purposes belong to the botanical families Cyperaceae, Thyphaceae, Poaceae and Juncaceae (De Stefani, 2012). The present review reports the results of a decade of experiments conducted on more than 30 phytodepuration plant species grown in FTWs in North Italy.

METHODS

Nine trials were conducted in North Italy from 2006 to 2016 both in full and pilot scales. During the experimental period, more than 30 plant species of different botanical families were grown on Tech-IA® support mats, an Italian patented floating system. Among used plant species, the most frequent were *Phragmites australis*, *Iris pseudacorus*, *Typha latifolia* and *Carex spp.* Urban and agricultural run-off wastewaters, sewage water, synthetic nutrient solution and diluted digestate liquid fraction derived from an anaerobic digestion plant were treated. Plant development was monitored by measuring survival rate, plant height, root length, dry biomass production above and below mats, and nutrient uptake in dry biomass.

RESULTS and DISCUSSION

Considering the main species, *T. latifolia*, *Carex spp.* and *P. australis* showed higher survival rates over growth seasons (56, 55 and 44% respectively). *T. latifolia* and *P. australis* reached significantly higher plant heights (median values of 175.0 cm and 120.0 cm) than those found for *I. pseudacorus* and *Carex spp.* (median values 43.0 cm and 65.5 cm). No differences in root lengths were detected among the main species (median value 50 cm). *T. latifolia* above mat dry biomass production (median value 608.4 g m⁻²) was significantly higher than that of *I. pseudacorus* (median value 208.5 g m⁻²), but not significantly different than those obtained for *P. australis* and *Carex spp.* (median value 327.6 g m⁻²). *T. latifolia* produced the highest root dry biomass (median value 4254.6 g m⁻²) followed by *P. australis* (median value 3010.9 g m⁻²). The lowest values were detected for *I. pseudacorus* and *Carex spp.* without any difference among them (median value 355.4 g m⁻²). *T. latifolia* and *P. australis* exhibited the highest nitrogen uptake through roots (median value 83.9 g m⁻²) and aerial parts (24.6 and 19.1 g m⁻² respectively).

Regarding the other species, *Canna indica* and *Pontederia cordata* showed good plant heights with median values of 124.0 cm and 104.5 cm respectively, whereas the

best root lengths were found for *P. cordata* and *Juncus effusus* (median values 64.0 and 60.0 cm). *C. indica* and *Mentha aquatica* produced the highest above mat biomass productions (median values 1513.4 and 3162.1 g m⁻²). *Sparganium erectum* and *Zantedischia aethiopica* did not survive during the growing season, hence showing the worst adaption to the FTWs.

CONCLUSIONS

Obtained results showed that: 1) within the main species, *T. latifolia* and *P. australis* showed the best adaption to FTWs both in pilot and full scale plants; 2) within the other species, good adaption rate were found for *C. indica*, *M. aquatica*, *P. cordata* and *Carex spp.*; 3) *S. erectum* and *Z. aethiopica* were not suitable for hydroponic conditions.

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F3 - Monitoring an early stage constructed wetland for the abatement of pollutants in agricultural drainage water

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INTRODUCTION

Constructed or semi-natural wetlands (CWs) exhibit a great role in the treatment of agricultural drainage water through the reduction of nitrogen (N) and phosphorus (P) loads and the protection of surface and ground water (Borin and Tocchetto 2007; Otto *et al.* 2016). Free water-surface CWs (FWS) are a class of horizontal constructed wetlands (Vymazal 2010) which is very effective in the removal of organic compounds by microbial degradation, suspended solids by settling and filtration through dense vegetation, and in the abatement of biological oxygen demand (BOD), total nitrogen (TN) and total phosphorus (TP) (Borin *et al.* 2001). Floating-treatment wetlands (FTWs) are innovative phytoremediation technologies integrated into CW systems. FTWs have been shown to abate 50% of TN and 22% of nitrates (NO₃⁻) in a 5-day detention period (Sun *et al.* 2009). The present study continues the monitoring of an early stage integrated constructed wetland system consisting of FWS and FTW CWs to evaluate its performance in reducing TN and NO₃⁻ in the water flow and to determine the survival rate, biometrics, biomass production and nutrient uptake of macrophyte species adapted to FTWs.

METHODS

A 3.2-ha integrated wetland system was established on a farm, ‘Tenuta Civrana’, within the Venetian Lagoon drainage system (north-eastern Italy) in 2014. The system was created by restoring a semi-natural wetland, originally consisted of two main trapezoidal basins (B1 and B2); further three sequential downstream basins (B3, B4, and B5) have been created incorporating five sub-basins into a FWS CW. At the outlet of the FWS system (B5 OUT), the water flows through a subsurface pipe into a vegetated channel, which has been used to create a second phytoremediation system, the FTW. It consists of a set of rectangular self-buoyant mats (TECH-IA) to support plants which are in turn divided into 3 major barriers (F1, F2, F3). The floating units were planted with seven different macrophyte species during the seasons 2014 and 2015. Between 2014 and 2016, water samples were collected periodically at the inlets and outlets of the FWS CW and the FTW and analyzed for N and P concentrations. In addition, some physicochemical parameters of water were measured to determine the water quality. Development of plants in FTW was monitored by measuring survival rates, plant height, root system length, fresh and dry biomass production above and below mats, and nutrient uptake in dry biomass. Results for the seasons 2014-2015 were reported by Pappalardo *et al.* (2017).

RESULTS and DISCUSSION

Reporting the results of 2016, the concentration of TN in FWS CW decreased from a median value of 6.61 ppm at B1 inlet to 3.35 ppm at B5 outlet. NO₃⁻ concentration decreased from 3.24 ppm at B1 inlet to 0.20 ppm at B5 outlet. Turbidity exhibited lower median values in 2016 (72.2 and 34.8 NTU at B5 outlet and F3outlet, respectively) while decrease in electric conductivity of water in FTW outlet was notable in 2016 (median value 792.2 μScm^{-1}) compared to 2014 and 2015 (median value 1211 μScm^{-1}) indicating more sediment stability.

Regarding macrophyte species in FTW, total survival rate for *Carex spp.* and *Lythrum salicaria* was 55% in 2016 compared to 82 and 95% for each of the species respectively in 2015. Survival rate for *Iris pseudacorus* was 12% in 2016 compared to 40% in 2015. Average plant height and root length remained the same for *Carex spp.* in 2016, while they decreased for *L. salicaria* and *I. pseudacorus*. Fresh above and below mat biomass production was almost doubled for both *Carex spp.* and *L. salicaria* in 2016 (medians 5289 and 1655 g m⁻², respectively). Dry above and below mat biomass production was doubled for *Carex spp.* (median 983 g m⁻²) compared to 2015 (438 g m⁻²), while it was indifferent for *L. salicaria* (250 g m⁻²). Nitrogen uptake above and below mats was doubled per square meter of dry biomass for *Carex spp.* in 2016 (median 9.28 g m⁻²).

CONCLUSIONS

1) Changes in TN and NO₃⁻ concentration were notable between 2014 and 2016; 2) Turbidity and electric conductivity are two determining parameters for water quality and.; 3) *Carex spp.* is the most adaptable species in FTW.

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D8 - Nutrient contribution by breeding waterbirds at Lake Lesser Prespa (Greece) and their influence on the water quality variables

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ABSTRACT

The Lake Lesser Prespa (or Mikri Prespa) in northwestern Greece is internationally acknowledged as an important habitat for protected migratory waterbirds. The most abundant species which are breeding in densely-populated colonies there are the Dalmatian Pelicans, the Great White Pelicans, the Pygmy Cormorants and the Great Cormorants. However, like many other lakes around the world, the water quality of Lesser Prespa is impaired due to the accelerated eutrophication. Long-term nutrient enhancement has led to incidences of nuisance blooms of cyanobacteria during the warm periods which may pose a serious health hazard to wildlife and humans due to the elevated co-presence of Microcystins (cyanobacterial toxin). The lake is strongly influenced by the constant fertilization of the adjacent bean monocultures but anthropogenic activities do not necessarily represent exclusively the total nutrient inputs in lake. Bird-induced nutrients via their daily excrements may trigger further the eutrophication processes. In this study we estimate the annual phosphorus and nitrogen input by the most abundant waterbirds (pelicans, cormorants) into the lake and also investigate their influence on the water and sediment quality. Field sampling along transects shows cumulative soluble nutrients at the lake sediments close to the bird-colonies while regular chlorophyll measurements indicate high algal growth near these sites in the summertime. Likewise, an algal growth assay shows that the direct addition of bird excrements in the lake water is stimulating conspicuously the growth of cyanobacteria up to 80,6 µg/l. The prospective nutrient input by both pelicans and cormorant species to the lake is expected to be at least 1,2 tons of Nitrogen and 1,6 tons of Phosphorus per year. The nutrient contribution made by the spectacular communities of these waterbirds may cause local habitat degradation and should be considered when deciphering the main sources of nutrient inputs of this lake system.

A3 - Remote sensing for the wise use of wetlands: 25 years of landscape changes in the Kilombero floodplain, Tanzania

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INTRODUCTION

Although the value of ecosystem services provided by wetlands is well demonstrated, they continue to disappear globally. Lack of spatial and temporal information to guide conservation and management strategies is a common challenge, especially in low income countries. The Satellite-based Wetlands Observation Service (SWOS) is working on several sites over the world to provide wetland managers with high cadence and high quality spatial information using freely available imagery. One of these sites is the Kilombero basin, in Tanzania. It is a Ramsar wetland of vital importance for several endangered and keystone populations of animals. It also provides several ecosystem services to human populations living in the basin and downstream. During the last 25 years, the area has experienced intense farm encroachment due to an increase of population, and the natural corridors going through the wetland have lost functionality (Jones et al. 2012).

METHODS

We use Landsat 5 and Sentinels-1 and -2 imagery from 1991, 2004 and 2015-16 to map and reveal Land Use Land cover trends in the Kilombero floodplain since the 90's. Training data is obtained from georeferenced oblique and vertical aerial photos. An object-based approach is used to divide the images into ecological meaningful units prior to classification, and a maximum likelihood algorithm is used to assign each segment to a class. These classes are afterwards aggregated into three; Open to close forest, arable land and wetland. The class wetland comprises water bodies, swamps, and grasslands, which are often inundated. Validation was performed using the platform Collect Earth (Bei et al. 2016).

RESULTS AND DISCUSSION

Farm encroachment has already transformed over 50% (350.000 ha) of the natural grasslands and wetlands in the floodplain during the last 25 years (Fig 1), and the trend is expected to continue. The global accuracy was 77%. Fusing mapping results from Sentinel-1 and Sentinel-2 we have been able to separate seasonally inundated grasslands from non-inundated grasslands. This is important for two reasons: inundated grasslands are vital for several endangered species of mammals (e.g. puku antelope), and these areas are unlikely to be transformed into farmland any time soon due to the high cadence of floods. However, climate change and water management upstream might change this in the future.

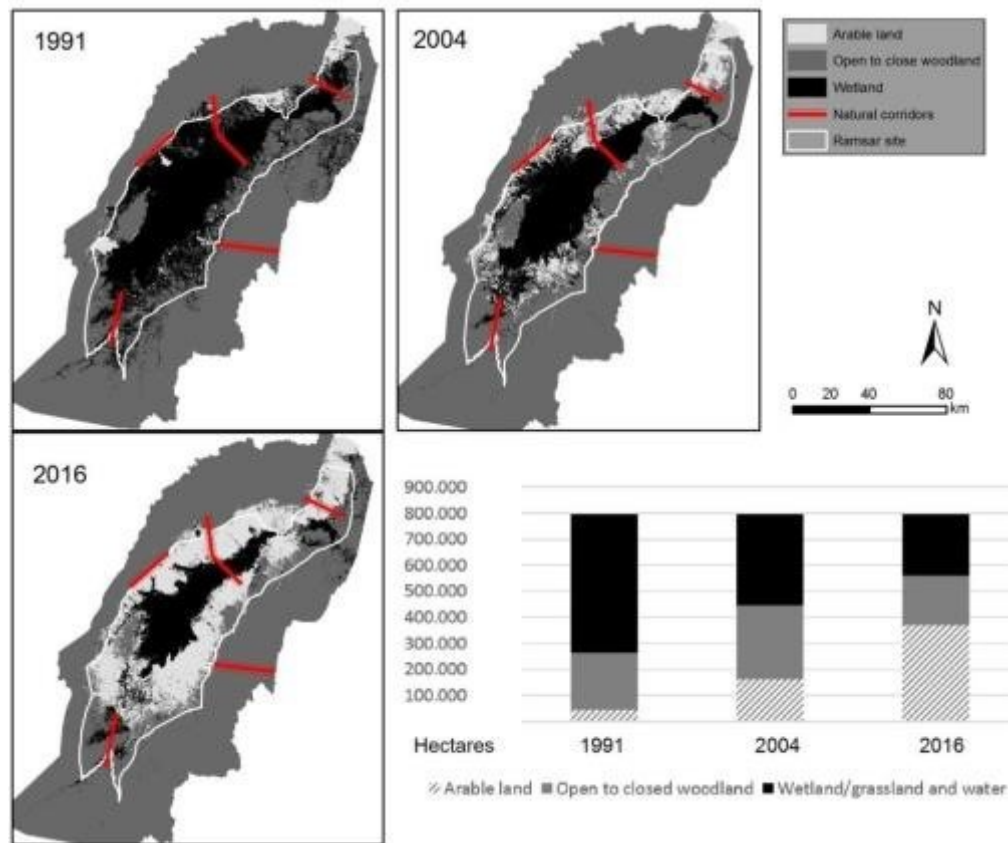


Fig 1: LULC categories in Kilombero floodplain, Tanzania. Maps and chart show how arable land as increased at the expense of wetlands and natural grasslands. Many of the natural corridors for fauna have lost functionality during the last years.

CONCLUSIONS

Farm encroachment has rapidly invaded the natural grasslands and wetlands of Kilombero since the 90's. This is causing habitat loss and fragmentation, which has had a negative impact in several ecosystem services (Jones et al. 2012). Operational monitoring services based on freely available remote sensing images are essential for wetland management. SWOS can provide managers with the spatial and temporal information they need, and support the wise use of wetlands.

ACKNOWLEDGEMENTS

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A5 - Island wetlands of Greece - From ignorance to international recognition

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INTRODUCTION

Efforts to create a national inventory of Greek wetlands began in 1980 (Dorikos 1981) and turned systematic by 1991 by the Greek Biotope/Wetland Centre. Finally, the inventory was finalized and published in 1994 with the support of the Greek State and thanks to the cooperation of dozens of services, organisations and individuals (Zalidis & Mantzavelas 1994). It includes a list of 378 wetlands with inventory data on 271 of them. With respect to the islands, it provides data for 70 wetlands located on 23 islands. While preparing the inventory, the main focus had been on the large and important wetlands of Greece's mainland while thousands of minor wetlands spread throughout the Greek territory failed to get the attention they deserved, leaving a gap in our knowledge of Greece's wealth in wetlands.

This knowledge gap in the number and state of wetlands was particularly poignant in the case of island wetlands, the vast majority of which were virtually nonexistent for the State. However, because they are isolated, island wetlands are extremely important, forming oases that burst with life. Yet due to their small size, such oases are vulnerable and greatly threatened by senseless human activity.

In an effort to fill this gap, in 2004 WWF Greece launched the "*Conservation of Aegean Island Wetlands*" project, striving to document the state of Greek island wetlands, highlight their importance and draw attention to whatever is needed for their preservation. In the course of the first two years 348 wetlands larger than 0.1ha were identified in 52 islands of the Aegean Sea (Crete excluded), 230 of which were inventoried following proper fieldwork. Initial inventory results were published in 2007 (Catsadorakis & Paragamian 1997).

In the years that followed, WWF Greece efforts intensified. In 2007, the scope of action was broadened so as to include all Greek islands. Under the "*Conservation of the Island Wetlands of Greece*" project, field visits enabled the creation of an inventory of almost all island wetlands, and a series of coordinated actions were performed, aiming at documenting them, informing, educating, and sensitizing the public, preventing their degradation and promoting an effective protection framework. Moreover, notable progress has been made: precious knowledge regarding the status, importance and value of island wetlands have been amassed, the issue of their conservation has been emerged into public dialogue, threats have been thwarted in a considerable number of cases and specific legal and management measures for their preservation have been promoted, both on a national and on a local scale. As a consequence of this project, the 12th COP Ramsar (Punta del Este, June 2015) adopted a resolution proposed by the Greek State.

This resolution acknowledges the crucial role the island wetlands of the Mediterranean and calls upon all the Mediterranean contracting parties for their protection.

METHODOLOGICAL APPROACH

During the project's first two years (2004 - 2006) efforts focused on developing internal capacities and infrastructures, so as to collect and analyze all data needed to properly document the wetlands' ecological statuses and to fully comprehend the problems they are facing. This allowed for the careful planning and implementation, later on, of a quite complex activities grid, aiming to mobilize the State and competent bodies, to ensure the establishment of special measures for the conservation of island wetlands, to promote their implementation and prevent or thwart dangerous threats.

These activities were planned and implemented in accordance to 4 objectives (Figure 1):

Inventory, documentation and dissemination of knowledge

Scientific work was built around research, identification, mapping and documentation. Preliminary identification of potential wetland sites were done using satellite, aerial images and high resolution photos, provided by Google Earth, Bing Maps, the Hellenic Mapping & Cadastral Organization and TripinView.com. Two main criteria were applied: No linear systems were included and the minimum wetland area inventoried was 0.1 hectares. More than 1000 sites on more than 70 Greek islands were visited and wetlands were inventoried and delineated. Data collected in situ and from relative literature were entered in 4 interlinked databases. Finally, all available information was disseminated through a WWF portal and a numerous national and international congresses and workshops.

Promotion and guarantee of adequate protection frameworks

Putting the project's inventory and cartographic data to good use, WWF Greece has sought institutional protection of island wetlands, on a local (spatial planning of the municipalities and region districts), national (inclusion in wild life refuges, laws and presidential decrees) and international scale (through Ramsar Convention), using a series of memoranda and interventions.

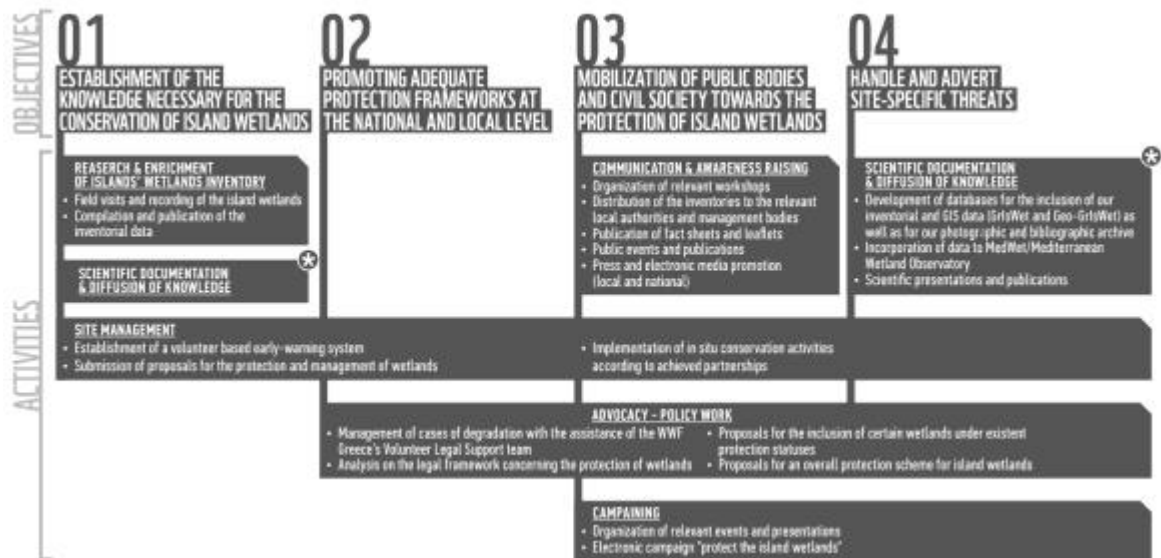
Diffusion of knowledge towards the mobilisation of public and civil society

Project results were publicized in an extensive and escalating manner, aiming at sensitizing the public, mobilizing citizens, and exerting constant pressure on decision makers. Numerous tools were used: public announcements to the media and press bulletins, interviews and articles to the press, publications, lectures, citizen group 'tours' to wetlands, posts on the WWF Greece site and blog, as well as extensive use of social networking media. In addition, partnerships were developed with Environmental Education Centers and the Scouts in an effort to convey the message to younger people.

Handle and avert site-specific threats during the project

A volunteer network developed gradually, covering 6 Aegean Sea islands, with the purpose to ensure timely detection of any degrading activity and to immediately inform the project's research team. After receiving proper training, volunteers visited wetlands, checking their status and reporting to the research team. Each time a degrading activity was detected, an official letter was drafted documenting the case, analyzing the legal framework, and raising specific issues, and finally sent to all competent public bodies

and authorities. In addition, in a large number of cases, WWF Greece performed studies and drafted technical reports on the protection, restoration and management of wetland areas.



PROJECT DELIVERABLES AND ACHIEVEMENTS

Inventory, documentation and dissemination of knowledge

Prior the project "Conservation of the islands wetlands of Greece", the information about the number and the condition of the island wetlands was limited. The National Inventory of the Greek Biotope/Wetland Centre published in 1994 listed 107 wetlands in 25 islands (Fig. 1) but the data provided were practically negligible. Nowadays, all the wetlands of the islands (>0.1 ha) are sufficiently documented while the methodology and the results of the project were presented and tested in several scientific congresses and workshops. In summary, after the completion of the project:

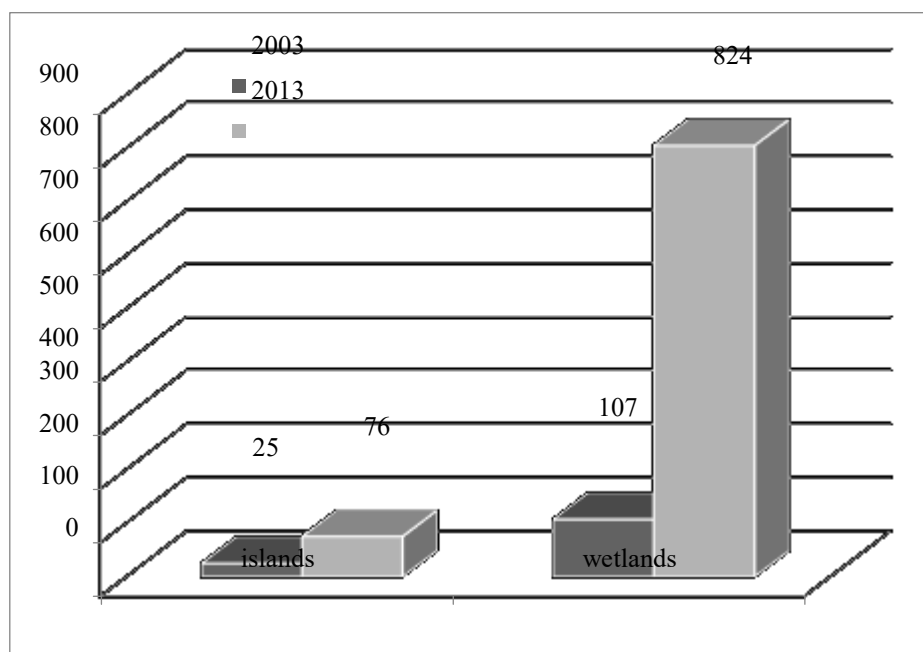


Fig. 1. Known wetlands before and after the project "Conservation of island wetlands of Greece"

- ✓ 824 natural and artificial wetlands (>0.1 ha) in 76 islands of Greece (100 on 8 Ionian Islands, 520 on 65 Aegean islands and 204 on Crete and 2 satellite Islands) have been documented and delineated. Of them, 602 are natural wetlands and 222 are artificial. More than 760 wetlands were visited, surveyed and inventoried, each time filling in a special inventory factsheet, supported by extensive photographic and video documentation. However, the inventory effort was by far bigger than that. In total, additional 291 possible wetland sites had been pointed on Google Earth with more than half of them been visited and excluded from the inventory, as they were small or destroyed or erroneously identified as wetlands.
- ✓ The outcomes of the project are freely available to all citizens, public authorities and scientists (Greeks and foreigners) through Ygrotopio (www.oikoskopio.gr/ygrotopio), a portal of WWF Greece for the island wetlands. Ygrotopio contains the inventory data of all 824 wetlands, both in English and in Greek and it is fully compatible to MedWet's database. Moreover it contains a photographic archive for all wetlands and basic statistical data depicted in charts.
- ✓ An inventory book has been published as a result of the first phase of the project (2004-2007) containing data for 348 wetlands in 52 islands of the Aegean Sea (Catsadorakis & Paragamian 1997).
- ✓ The results of the project have been communicated to the scientific community through 30 oral and poster presentations to 19 scientific congresses.
- ✓ Three papers have been published in scientific journals/proceedings (Paragamian & Catsadorakis 2007; Paragamian 2009; Georgiadis et al. 2010a).
- ✓ Data have been used in the compilation of 5 master and graduate thesis in 3 University institutions of Greece.

Promotion and guarantee of adequate protection frameworks

Policy work resulted in a significant increase of protected island wetlands (Fig.2). Out of 824 wetlands, 565 (~70%) are now under protection with a strict legal framework. However, if focused only in the natural wetlands, more than 80% (482 out of 602) are protected by the same protection statuses. The greatest achievements of the project are summarized as below:

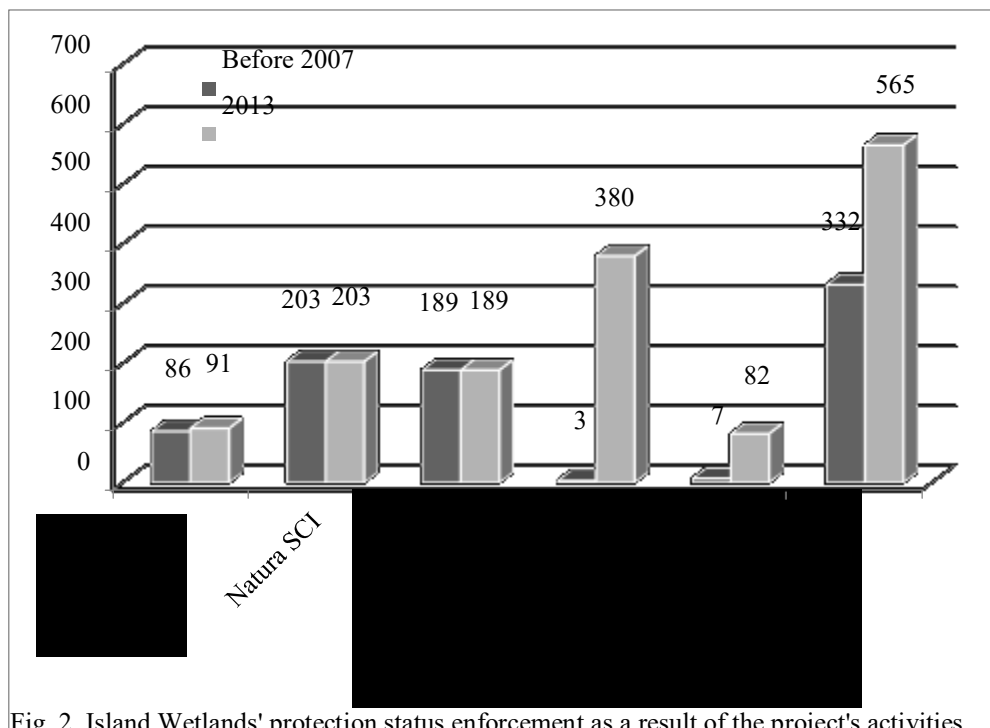


Fig. 2. Island Wetlands' protection status enforcement as a result of the project's activities

- ✓ The Greek Biodiversity Law approved in 2011 included an article for the protection of all island and mainland wetlands and foresaw the preparation of a Presidential Decree for the protection of the small island wetlands (<8 ha) and a ministerial decision for the protection of the wetlands >8 ha.
- ✓ In 2012 the Presidential Decree "Approval of a list of small island wetlands, and provision of terms and conditions for the protection and conservation of small coastal wetlands included therein" was signed bringing 380 natural wetlands across 59 islands under a strict protection status.
- ✓ 74 wetlands were included as protected areas in approved Spatial Plans (PSSOOCs and GUPs) in 6 islands while additional 5 were included in a new established Wildlife Refuge at Lesvos Island.
- ✓ In 2015, after the submission of the Greek State, the 12th meeting of the Ramsar COP (Punta del Este, Uruguay), adopted the Resolution XII.14 "Conservation of Mediterranean Basin island wetlands"

(www.ramsar.org/sites/default/files/documents/library/cop12_res14_med_islands_e.pdf).

Diffusion of knowledge towards the mobilisation of public and civil society

Communicating the importance of the island wetlands and working with communities in a regional and local scale was especially important for achieving the final goal which was the institutional shielding of the wetlands. By following this strategy, i.e. working from bottom up with individuals and local and regional authorities, the intention was to put pressure for the optimal result at all levels. Overall, through the various activities of the project, activities and results of the programme were communicated to:

- ✓ more or less 10,000 people through presentations, seminars, action days etc.

- ✓ 6.000-10.000 unique visitors per month (since 11/2009) through WWF's blog (<http://wwfaction.wordpress.com/>)
- ✓ more than 23,000 people through the distribution of informative leaflets
- ✓ 35,000 WWF Greece's supporters that receive the quarterly magazine "Living Planet"
- ✓ an uncountable number of people as interviews in TV/radios and the reposts of blog articles to other web sites have never been recorded
- ✓ an uncountable number of people through 13 popularized articles in various popular magazines
- ✓ public services, primary and secondary schools, environmental education centers etc., in where 7,500 copies of book and booklets have been distributed

Communication efforts were constantly increasing from 2004 showing a peak in 2011 (Fig. 3), the year that the Presidential Decree was drafted and presented for public consultation. Indicatively the following chart presents the people attended in presentations, seminars and field events/actions days from the start of the project until its completion.

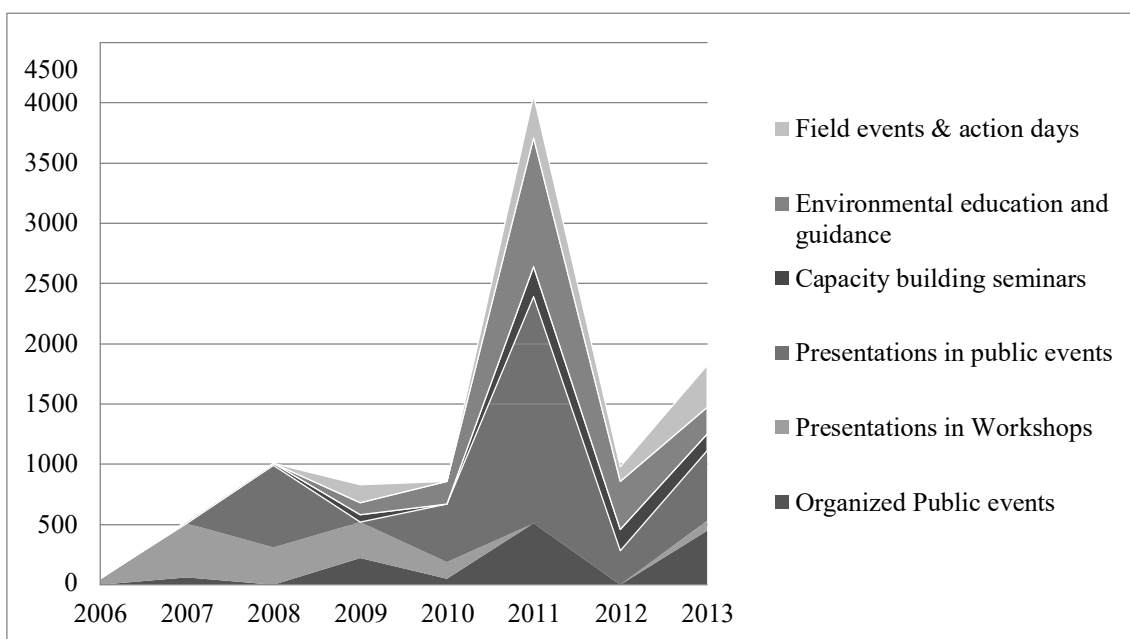


Fig. 3. Number of people attended to various communication activities of the project

Some of the most significant actions under this objective were:

- ✓ The development of a volunteer network covering 7 islands (Lemnos, Lesvos, Paros, Andros, Skyros, Kos & Crete). Volunteers participated in numerous public events and presentations, field events and action days. 1000 scouts from Crete participated in this network as they adopted 10 natural wetlands.
- ✓ A tale and video competition for the students of the schools of Crete, Lesvos and Paros island was organised under the title "Wetlands: a story for my island". The main objective of the contest was to inspire the students to discover the wetlands of the island, appreciate their values (ecological, economic, social), understand the threats and the need for protection and finally to create their own narrative for a wetland.

- ✓ The booklet “Wetlands of the Aegean” was published (Catsadorakis & Paragamian 2006) and distributed through the Primary and Secondary Education to the schools of the islands of the Aegean Archipelagos.
- ✓ Continuous support to the Regional Network of Schools for the monitoring of the Cretan wetlands. This Network was established with the participation of 49 schools and 4 environmental educational centers of the southern Aegean islands. A small thematic guide/educational material was produced and distributed to the schools of the network (Paragamian et al 2011).
- ✓ A guide for citizens under the name “Wetlands of my island: how can I recognize degradation activities and help for their conservation?” (WWF Greece 2017) was published and distributed to active citizens, NGOs and environmental education centers.

Handle and avert site-specific threats during the project

Degradation of island wetlands due to human intervention was really extended, thus immediate actions were needed to slow it down while examples of good protection and ecological management were also sought. Overall, actions were performed in more than 15 islands either by denouncing degradation activities, or by collaborating with public services, NGOs and citizens in restoration activities (Fig. 4). In summary:

- ✓ >200 cases of degradation in >70 wetlands with complaints letters to public services and the attorney were stopped.
- ✓ 4 studies for restoration and management of 13 wetlands were prepared (Georgiadis et al 2010b, Paragamian et al 2010a, Paragamian et al 2010b, Paragamian et al 2014) and finally 2 of them were partially implemented in 2 wetlands in Crete.
- ✓ Lighter conservation activities took place for several wetlands, especially in Crete, involving citizens, public authorities and NGOs.

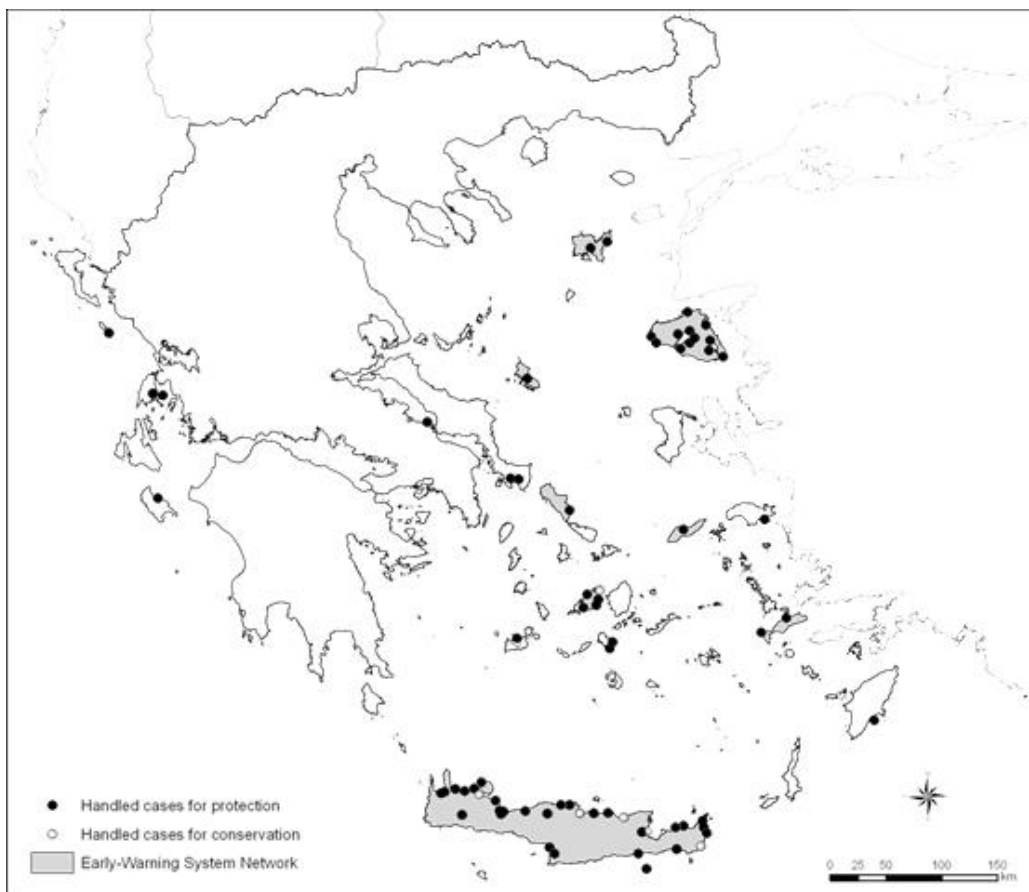


Fig. 4. Location of handled cases of degradation and conservation

THE NEXT STEPS

WWF Greece's work for the protection of the Geek island wetlands was no easy task. When the project started in 2004 no one knew how many island wetlands existed or where they were. This fundamental knowledge gap was eventually filled through systematic field research and led to the recording of the ecological status of 824 wetlands on 76 Greek islands. However, the project, not only documented the presence of the island wetlands, but also highlighted their importance as a network. More focused scientific works based on the data derived from WWF Greece's project showed that small island wetlands are extremely significant in terms of biodiversity (Aspradaki 2013, Pavlou et al 2015, Pavlou 2016).

The significance of the island wetlands and the urgency to conserve them were recognized through a resolution that was unanimously adopted by 12th Conference of the Parties (COP12) to the Convention on Wetlands of international significance (Ramsar, Iran, 1971). This resolution refers to the Mediterranean Basin as a global biodiversity hotspot and a leading tourist destination in the world. Following, it calls upon Contracting Parties to address the significant human-induced pressures threatening island wetlands through effective and decisive legislative while developing more long-term and integrated strategies or plans, so as to ensure the conservation of their biodiversity, and the maintenance of their hydrological, cultural and social values".

Following this resolution, all 8 Mediterranean countries (apart from Greece) that host island wetlands showed strong interest to replicate the Greek project. So far, Cyprus has already completed the inventory and in the next phase the Cypriot NGO "Terra Cypria"

will undertake advocacy and policy actions to ensure their legal protection. Additionally, inventories have already started in the Balearics (WWF Spain) and in Croatia (Association Hyla) while funds have already been secured for the rest of the countries (Turkey, Italy, France, Malta, and Tunisia). The data, with a robust scientific base, will be made available to managers, scientists and the general public in a shared Mediterranean data base.

The work of environmental NGOs and private funds are being instrumental in this new phase. Although a relevant step forward, acquiring the knowledge of the number and location of these wetlands, and gathering information on their values, uses and pressures, does not secure their protection. More actions are needed, especially coming from the involvement of public administrations both in national and Mediterranean/European level. The Ramsar Resolution XII.14 “Conservation of Mediterranean Basin island wetlands” clearly states what should be the next steps, starting with the necessary protection and restoration of island wetlands, the integration of the conservation needs of the wetlands within land use and water use plans and policies, and the recognition, in national and international instruments, that these special ecosystems, although in some cases small, have an enormous value for the conservation of the Mediterranean biodiversity.

ACKNOWLEDGEMENTS

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F1 - How is metal speciation affected by halophyte cover in different morphology salt marshes?

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INTRODUCTION

Salt marshes are considered natural sinks for pollutants (Caçador et al., 1993, 2000), functioning as buffers. Environmental conditions provided by salt marshes (both biotic and abiotic) are known to affect metal concentration and speciation in sediments. The elevational gradient along the marsh and consequent differential flooding are some of the major factors influencing halophytic species distribution and coverage due to their differential tolerance to salinity and submersion. Different species, in turn, have distinct influences on the sediment's metal speciation and accumulation (Reboreda and Caçador, 2007; Reboreda *et al.*, 2008).

METHODS

The present work aimed to evaluate how different halophyte species in two different salt marshes (Rosário and Hortas salt marshes, Tagus Estuary, Portugal) could influence metal partitioning in the sediment at root depth, and how that could differ from bare sediments. Metal speciation in bare sediments (“mud”) and in sediments around the roots (rhizosediments) of *Halimione portulacoides* (*H.p.*), *Sarcocornia fruticosa* (*S.f.*) and *Spartina maritima* (*S.m.*), was determined by sequentially extracting operationally defined fractions with solutions of increasing strength and acidity (Forster, 1995).

RESULTS and DISCUSSION

Rosário salt marsh generally showed higher total concentrations of all metals in the rhizosediments. The two areas present distinct characteristics that influence a higher metal enrichment in Rosário, compared to Hortas, namely higher TOM and greater proportion of finer particles. Metal partitioning in sediments from Hortas salt marsh was more variable than in Rosário sediments, but nonetheless similar trends were observed. Metal partitioning was primarily related to the type of metal, with the elements' chemistry overriding the environment's influence on fractionation schemes. The most mobile elements were Cd and Zn, with greater availability being found in non-vegetated sediments (Figure 1). Immobilization in rhizosediments was predominantly influenced by the presence of Fe and Mn oxides, as well as organic complexes. In the more mature of both salt marshes (Rosário salt marsh), the differences between vegetated and non-vegetated sediments were more evident regarding *S. fruticosa*, while in the younger system (Hortas salt marsh) all halophytes presented significantly different metal partitioning when compared to that of mudflats.

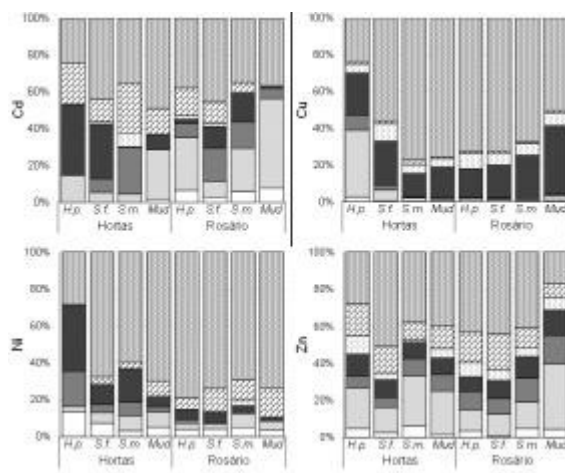


Fig. 1. Metal partition in the rhizosediments of *Halimione portulacoides*, *Sarcocornia fruticosa*, *Spartina maritima* and bare sediments, in Hortas and Rosário salt marshes. F1 □ Easily exchangeable metals; F2 □ Bound to carbonates; F3 ■ Bound to Mn oxides; F4 ■ Organic complexes; F5 ■ Bound to amorphous Fe oxides; F6 ■ Bound to crystalline Fe oxides; F7 ■ Residual metals.

CONCLUSIONS

The results found in this work show that general trends in metal partitioning occur regardless of the area or sediment vegetation cover, pointing to a greater importance of the metal chemistry in such processes. Salt marsh morphology or colonizing species were clearly of minor importance in the mobilization of Ni and Cu. Nevertheless, a closer look within each marsh type showed that metals with greater mobility were also more influenced by the type of vegetation cover (or its absence). That was the case for Cd and Zn, which presented higher mobility within sediment geochemical fractionation. Overall, although the characteristics of metals constrain their chemical binding forms within the sediment matrix, the marsh morphology must not be ignored as a major factor modulating the sediment composition and thus the availability of metal binding forms.

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E2 - New data on distribution of *Apium repens* (Jacq.) Lag in the Slunjčica River, Croatia

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INTRODUCTION

Creeping marshwort, *Apium repens* (Jacq.) Lag. (Apiaceae) is listed in the national Red Lists of all the countries where it occurs (Burmeier and Jensen, 2008) as well as in Annexes II and IV of the European Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora of the European Community (EC Habitats Directive). In the Red Book of Vascular Flora of Croatia it is listed as Data Deficient (DD) species (Nikolić and Topić (eds.), 2005).

Species *Apium repens* grows on wet and aquatic habitats. In Croatia it is distributed mostly along karstic rivers and it is limited to no more than ten localities. Even though the species is abundant in most of these localities, its geographical range in Croatia is relatively small. After year 2006, more intense field investigations of the species have been conducted for the purpose of identifying potential Sites of Community Importance (pSCI) for the Natura 2000 network. Occurrence of *Apium repens* was then also confirmed on river Slunjčica (Boršić et al., 2012).

River Slunjčica is karstic river, tributary of river Korana, 6,5 km long and located in the Kordun region in central Croatia. River Slunjčica is area protected in the category of significant landscape and as Natura 2000 site. We predicted that the species is distributed along the entire course of the river and gathering data to confirm that was the aim of this study.

METHODS

Field investigation was performed in the autumn of 2016 from the boat, with the purpose to record and map distribution of Natura 2000 species *Apium repens* along the course of the river Slunjčica.

The assessment of *A. repens* and abiotic parameters followed a standard approach (Nikolić, 2006) which was modified for this research. Studied aquatic habitat, with a total length of 6,5 km, was divided into survey units (~ 65 m in length). For every survey unit we estimated: cover, shade over riverbed, flow class, occurrence of macrophytes, mosses, algae, sediment type, land-use type, depth and water level. Cover is measure which determines % of area covered with plants as if observed in layout. We estimated cover with *A. repens* plant stands according to Braun-Blanquet five-point-scale in each survey unit: 1 (1-10 %), 2 (10-25 %), 3 (25-50 %), 4 (50-75 %) and 5 (75-100 %).

RESULTS AND DISCUSSION

The study determined occurrence of the species *A. repens* on 52 of 96 survey units in total, investigated along the course of the river Slunjčica, which means that the species

occurs on 54,16% of the river. Estimated cover ranged from 1 to a maximum of 5 in some survey units. Distribution was not continuous.

Taking into consideration observed threats on habitat types where *Apium repens* occurs, we can assume that populations of *A. repens* on these localities are also affected. *A. repens* is vulnerable to pollution and eutrophication. Main threats observed on the river Slunjčica are inadequate treatment of municipal waste water, uncontrolled dumpsites, agricultural areas along Slunjčica and state road D1, which partly runs along the border of protected area and Natura 2000 site and very close to the river.

CONCLUSIONS

So far, in the area of the river Slunjčica there was no systematic research conducted for the purpose of recording distribution of *Apium repens*. Newly gathered results are significant contribution to assessment of the status of this species in Croatia and to establishment of effective conservation management for *Apium repens* on the Slunjčica Natura 2000 site.

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B3 - Comparison of vegetation on three recovering milled peatlands in comparison with pristine bogs

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INTRODUCTION

Peatlands cover extensive areas in Northern Europe, but most of them have been disturbed by drainage for forestry, agriculture or peat excavation. Bogs in natural state are carbon sinks, but drained milled peatlands are carbon sources. One of the purposes of peatland revegetation is to restore carbon balance which is characteristic to pre-disturbance (peat mining) (Pfadenhauer & Grootjans, 1999). Other important indicator of successful restoration is vegetation cover and distribution of phytomass between plant functional types that is characteristic to pristine peatlands (Lucchese et al., 2010; Waddington et al., 2011). Also Sphagnum species establishment has been considered to be crucial for peatland restoration (Rocheftort, 2000).

One of the principal indicators of a successful recovery is biological diversity and community structure similar to the nearby peatlands in pristine state (Pfadenhauer & Grootjans, 1999; Gorham & Rocheftort, 2003). The main aim of this study is to compare the vegetation of restored milled peatlands to nearby pristine bogs. This signals the recovery of vegetation and success of the restoration activities.

METHODS

Plant cover and biomass analysis was conducted on three sites. All sites divide into recovering milled peatland and pristine bog, which are situated close by. The maximum distance between the restored and pristine site is 650 meters. All sites are in Northern Europe, Estonia.

Kõrsa site (58°23', 24°41', height above sea level is between 13,5- 15,0 m) is self-recovering site in Southern Estonia. The site has been abandoned for about 30 years. Hara site (59°33', 25°39', height above sea level is between 27,5- 29,0 m) and Viru site (59°28', 25°39', height above sea level is between 53,5- 54,0 m) are in Northern Estonia. Viru site was restored in 2008 using the moss-transfer technique (Rocheftort et al. 2003). In Hara site water table was raised by damming the ditches in 2012.

The vascular plant samples for biomass measurements (N= 30) and plant cover of under-story was determined on all sites (three restored and three pristine) in July-August, 2016. Bryophyte samples (N=90) were collected in October, 2016.

RESULTS and DISCUSSION

The cover of some plant functional types (PFT) (Sphagnum species, true mosses and shrubs) differed statistically significantly ($p < 0,05$) between the restored and pristine sites (Fig. 1). The biomass difference of PFT-s between the pristine and restored plots was not significant, when all three sites were analysed together. In Hara site, shrub biomass ($1,3 \pm 0,7$ g dm⁻²) was significantly higher in pristine site, because shrubs were

absent from the restored site. In Viru, vascular plants (shrub and herbs) had significantly lower biomass in restored site. The shrubs like *Calluna vulgaris* need aerated conditions and are also slow growing. So it could be expected, that shrub biomass and cover will increase with time and with growing Sphagnum mats that will rise the Sphagnum surface higher from the water table and creates micro- topographical variability.

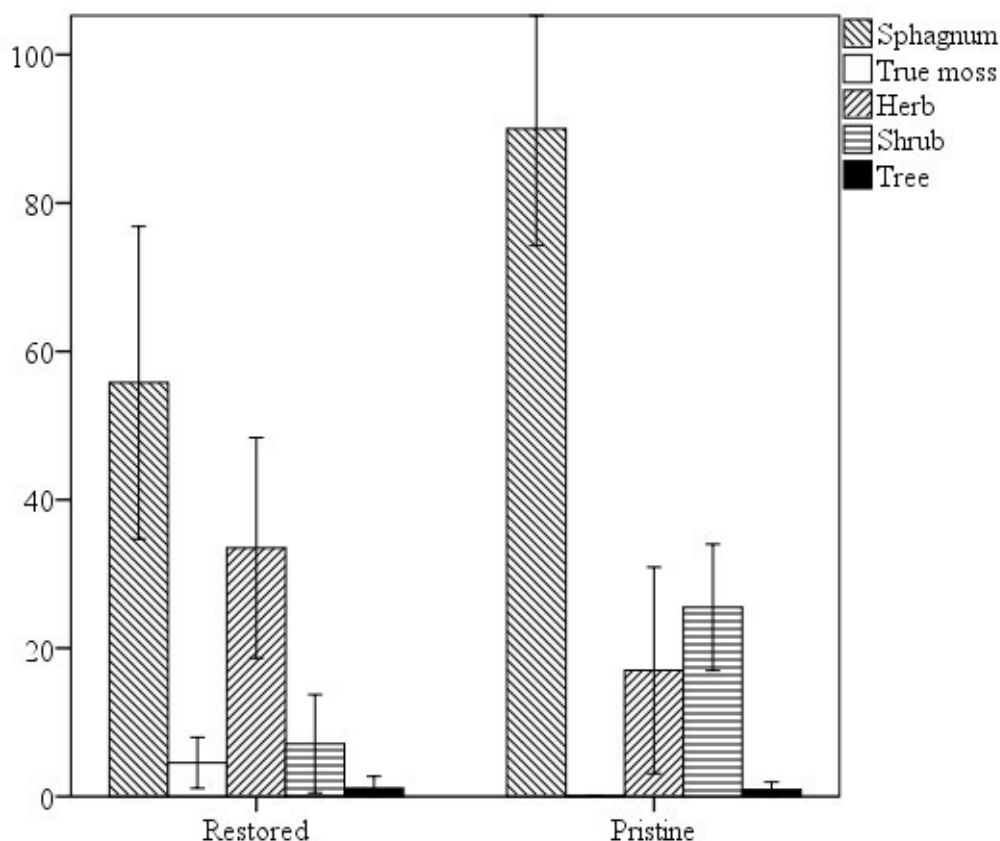


Fig. 1. Plant cover (%) of restored milled peatlands and bogs

Production of *Polytrichum strictum* was significantly lower on pristine sites than in restored sites. This true moss is the main pioneer bryophyte on milled peatlands, and with its ability to mitigate the harsh environmental conditions in these areas, it has been considered to be the nurse-plant for Sphagnum (Groeneveld et al., 2007). In bogs, *P. strictum* grows on hummocks, so it is adapted also to lower water table.

There were no statistically significant differences in Sphagnum production between the restored and pristine sites. This could be the result of higher water table on some of the restored sites (Kõrsa and Hara) than in respective pristine sites. It is supported by Ilomets (1974) who also measured high Sphagnum productions on hollows of pristine bog. In restored sites, increased Sphagnum production could be the result of presence of highly productive species like *Sphagnum riparium*, *Sphagnum angustifolium* and *Sphagnum fuscum* (Lindholm & Vasander, 1990) that could compensate the absence of Sphagnum from some plots in restored sites.

Principal Component Analysis indicated that the vegetation on restored sites varied mainly on axis characterised by nutrient richness. This could be the result of differences in substrate — in Viru and Hara restored site, the topmost peat consists of Sphagnum peat, in Kõrsa it is more nutrient rich. Also the upper mineralized peat layer has not

been removed from the restored sites. Variations in vegetation of pristine sites could be explained primarily by differences in water table (hummock and hollow vegetation) and all these pristine sites are nutrient-poor sites with Sphagnum peat.

The vegetation of the restored sites is not yet similar to the pristine sites, although Sphagnum cover is about 100% in restored Kõrsa site and on almost half of the plots in restored Hara and Viru site. Also the production of Sphagnum does not differ between the restored and pristine site. Still, probably more time is needed for the development of species and plant functional type structure on restored sites that is similar to the pristine sites. The need for long- term monitoring and clear restoration aims is also emphasized in Andersen et al. (2016).

CONCLUSIONS

The development of vegetation structure similar to pristine peatlands after the restoration activities is a slow process, so long-term monitoring (over ten years) is needed to evaluate the restoration success on these sites. Also precise restoration goals should be established, as the Sphagnum carpet can develop rather quickly in suitable conditions, but its species composition may not be similar to the vegetation that was there before the peat excavation and still is on nearby pristine sites. Also it takes more time for the return of some plant functional types, for example, shrubs.

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D5 - A cheap and cheerful way to improve water quality and enhance biodiversity: The Frogshall Integrated Constructed Wetland

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INTRODUCTION

Integrated constructed wetlands (ICWs) have been implemented widely in Ireland and elsewhere (Babatunde, 2008; Boets et al., 2011; Everard et al., 2012). There is strong evidence that they can deliver on a variety of water quality objectives, including reducing nutrient levels (Harrington and McInnes, 2009) as well as delivering significant nature conservation outcomes (Jurado et al., 2010). There is also good evidence that implementing ICWs may provide the highest utility in comparison with both cost (Doody et al., 2009) and overall environmental performance (McInnes et al. 2016).

This paper provides an initial assessment of the ability of an ICW in Norfolk, UK, to improve water quality discharging from a small rural sewage treatment works (STW) and the associated changes in species populations and biodiversity recorded pre- and post-construction. Comments are also provided on the cost and benefits of this approach.

METHODS

Ecological surveys and water quality monitoring were conducted before and after the construction of the ICW. Monthly water samples were collected between December 2013 and June 2015. Thereafter samples were taken in October 2015 and July to September 2016. Following construction, samples were collected monthly from December 2014 to June 2015 and then in October 2015 and July to September 2016. Analysis was performed for total phosphorus (TP), orthophosphate, total oxidised nitrogen (TON), nitrate, ammoniacal nitrogen. Ecological surveys were conducted annually on birds and in-stream aquatic invertebrates using standard field survey techniques.

RESULTS and DISCUSSION

All nutrients were significantly lower in the effluent from the ICW as compared to the influent received from the STW, with reductions ranging from 62 – 80 % ($P < 0.05$ to $P < 0.001$). Interestingly, there were no significant reductions in nutrients in the downstream receiving watercourse after wetland commissioning, and ammoniacal nitrogen increased.

Ten species of bird were recorded on the site in 2014, prior to the installation of the ICW. After the ICW was installed, bird species diversity increased unsurprisingly to 29 species in 2015, with 27 species recorded in 2016. There was a clear increase in

invertebrate density and biomass in the downstream environment, when compared to a control stream in an adjacent catchment, suggesting that changes in water quality had assisted in improving invertebrate populations.

The total cost of implementing the ICW was in the region of £40,000 (€47,000). The wetland also provides an uplift in the ecosystem services the area provides from pre- to post-construction. When compared against the multiple benefits the wetland provides or the cost of traditional approaches to phosphorus removal from rural STWs, such as through chemical precipitation, this approach could be considered cheap and cheerful.

CONCLUSIONS

The ICW reduced nutrient concentrations across the wetland and to some extent in the receiving waterbody although the latter result was non-significant. The ICW also demonstrated improvements in biological indicators as a result of the habitat changes and the water quality improvements. When compared against the initial costs, the implementation of an ICW can be considered as cost-effective solution which has the potential to provide multiple benefits.

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A4 - Testing (new, easy, efficient) tools for assessing the ecological status and threats of Mediterranean wetlands

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Management of wetlands requires easy and efficient tools for monitoring and evaluating the conservation status and the major threats affecting these aquatic ecosystems. Following European Directives, monitoring must include hydromorphological, physical, chemical and, overall, biological parameters. With focus on Spanish aquatic ecosystems, and supported by the Conservation Department of the Spanish Ministry of Environment, we have developed a system of evaluation of the ecological status of aquatic systems that accomplishes all these requirements. In this work we presented the results of evaluation system applied to selected Spanish Mediterranean wetlands.. Nowadays, many of these ecosystems are remains of ancient extended coastal wetlands. They are characteristically shallow, from fresh- to brackish or saline waters, with important water level fluctuations, and support a high biodiversity with notable endemic taxa. Eutrophication and salinization remain as major threats overall, however water input reduction, due to climate change and/or human demand, besides the presence of exotic species, maybe the most important threats for future years. Remote sensing techniques are also being developed in order to determine the hydrological dynamics of these wetlands, both under natural and altered regimes, and to know how these dynamics are related to meteorological conditions and to human impacts.

E5 - Wilde Mulde - re-vitalisation of a dynamic riverine landscape and possible effects on sediment and contaminant dynamics in floodplains

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Riverine landscapes are unique habitats that coevally provide an extraordinary amount of ecosystem functions and services on varying spatial and temporal scales. Necessary requirements are the interaction between hydro-geomorphology and ecological processes as well existing connectivity between rivers and their adjacent floodplain.

Against this background this project aims to implement several re-vitalisation measures along the River Mulde in Central Germany. It is planned to install dead wood in the river bed, restore unfixed riparian banks, connect a former river branch and initiate the development of a hardwood forest.

As those measures will mainly influence biodiversity as well matter and sediment dynamics the project will gather a deeper knowledge regarding the processes that possibly have favoring effects of the maintenance and recovery of ecosystem functions and services in river-floodplain ecosystems across several habitats.

The floodplains along the Mulde River are distinctly polluted by several contaminants. Thus in this paper we want to focus on the investigation of matter dynamics concerning re- mobilisation as well retention of sediments and pollutants in floodplains influenced by the restoration of unfixed banks.

Within the floodplains we collected data about soil characteristics (e.g. grain size, bulk density) and amounts of trace elements and organic pollutants in a reference site as well in the site where unfixed riparian areas will be restored. Further, in both areas, we want to use sediment traps to collect transported sediments and bound pollutants during flood events. At the same time water samples will be collected in the river Mulde itself to get information about transported contaminants and sediments during flood events.

Within the floodplains first data show divers pattern; soil substrates, and thus pollutant distribution, change on short distances. By using sediment traps we want to try to describe this heterogeneity and further quantify sediment and contaminant input. Along the river banks first aerial image evaluation along the reference site show that lateral erosion occur regularly and lead to distinct bank shifts. By mapping horizon dependent soil characteristics along the banks of the reference site as well the site with the planned re-vitalisation measure we hypothesize that sediment as well pollutant transport during flood events can be quantified and effects of the planned revitalization measure on the transported amounts can be monitored and calculated.

D3 - *Typha latifolia*: The importance of phosphorus co-limitation of the leaf photosynthesis-nitrogen relation and growth

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INTRODUCTION

Paludiculture is the cultivation of wet and rewetted peatlands. The aboveground biomass can be used for biofuel while some biomass is left to maintain peat formation. To maximize primary production and nutrient removal it is important to understand responses to nutrient availability for various plant species that can be used for paludiculture. The photosynthesis-nitrogen (N) relationship is an important trait characterising plant responses to soil fertility and especially the supply of N, the main growth-limiting nutrient. Interactions between N and P supply in controlling photosynthesis and growth responses remain poorly understood, and here were tested for *Typha latifolia*, a productive wetland species well-suited for paludiculture.

METHODS

Plants of *T. latifolia* were grown at three P levels (0.1, 1.0 and 10 mg PO₄³⁻ L⁻¹) and three N levels (1, 20 and 70 mg NH₄NO₃ L⁻¹) in a factorial experiment. Biomass, growth rates, maximum photosynthesis rates, and the photosynthesis-N relationship were compared.

RESULTS and DISCUSSION

The relative growth rate was enhanced by increasing P and N supply and low P-availability increased allocation of biomass to rhizomes and roots. Photosynthesis was related to N-availability and there was a strong interaction between N and P supply, with the slope of the photosynthesis-nitrogen relation significantly affected by P. There were also significant interactions between N and P supply for growth rates (Fig. 1). Responses of both growth and photosynthesis to N were constrained by low P supply.

CONCLUSIONS

T. latifolia is extremely responsive to nutrients compared with other candidate plants for paludiculture, and is likely to be most suited to soils with high availability of both N and P. In P- deficient soils, growth responses to N can be inhibited by low P, and this is reflected in both photosynthesis and growth data for this species. More generally, the study supports the principle that even fast-growing wetland plants that are normally limited by N supply can experience P deficiency, with the photosynthesis data suggesting that the most likely mechanism of P limitation being limited regeneration of ribulose-1,5-bisphosphate in the Calvin Cycle.

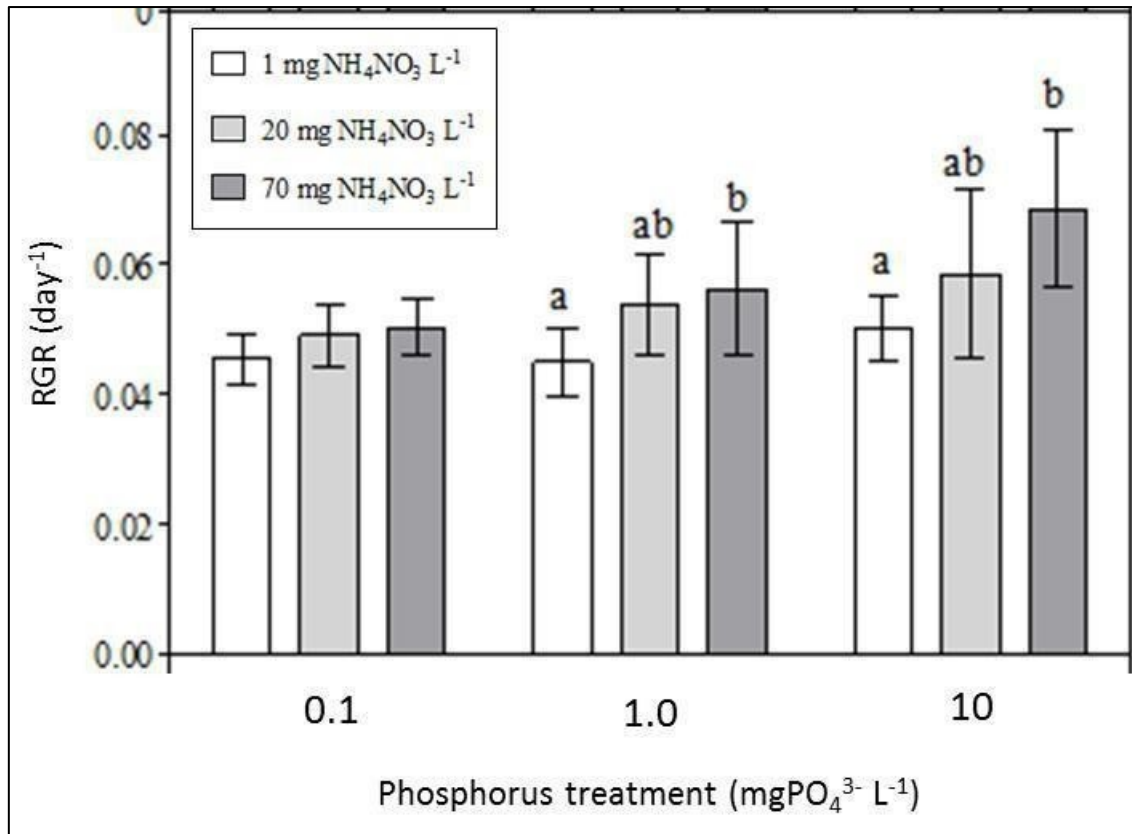


Fig. 1. Relative growth rate (RGR) of *Typha latifolia* in a factorial (N × P) growth experiment under three N and P concentrations. Mean values ± 1SD, $n = 7$. Different letter superscripts indicate significant effects of N on RGR within P treatments.

ACKNOWLEDGEMENTS

The research was funded by Innovation Fund Denmark for the project “CINDARELLA: Comparative analysis, INtegration and ExemplaRy impleMentation of cLimate smart LAnd use practices on organic soils: Progressing paludicultures after centuries of peatland destruction and neglect” (4215-00003B) in the framework of the programme FACCE ERA-NET Plus on Climate Smart Agriculture (FACCE Plus). Franziska Eller was granted a Postdoctoral Fellowship by the Carlsberg Foundation (CF15-0330) for the project REENEW - Reed as a renewable bioenergy- resource under acclimation-constraints to a changing World.

B2 - Polyphenols as enzyme inhibitors across a gradient of low to highly degraded peat soils: Implications for microbial metabolism in rewetted fens

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INTRODUCTION

Last 30 years, more than 30,000 ha of drained minerotrophic peatlands (= fens) in NE Germany have been rewetted to restore their ecological functions. Due to an extended drainage history, a re-establishment of their original state is not expected in a human life time perspective. Elevated concentrations of dissolved organic carbon, ammonium and phosphate have been measured in the soil porewater of the upper degraded peat layers of rewetted fens at levels of one to three orders higher than the values in pristine systems; an indicator of increased microbial activity in the degraded topsoil. However, there is evidence that the substrate availability within the degraded peat layer is lowered since the organic matter has undergone mineralization over the decades of drainage and intense agricultural use of the areas. Therefore, the pool of soil organic matter (SOM) is expected to become enriched in polyphenolic molecules, e.g. lignin or tannins (Fig.1), compounds that are usually associated with increased SOM recalcitrance. On the other hand, it has been shown before that the polyphenol-induced inhibition of hydrolytic enzymes that are integral to anaerobic OM decomposition is suspended during aeration of peat soils, mainly due to enzymatic oxidation of the polyphenols themselves, e.g. by phenol oxidase. Accordingly, we hypothesised that degraded peat substrate of rewetted fens contain less enzyme-inhibiting polyphenols, compared to less degraded peat substrate of more pristine fens. One of the proposed inhibitory effects of polyphenolics is the precipitation of enzymes, a process which can be easily detected by our tongue drinking dry red wine (Fig. 1).

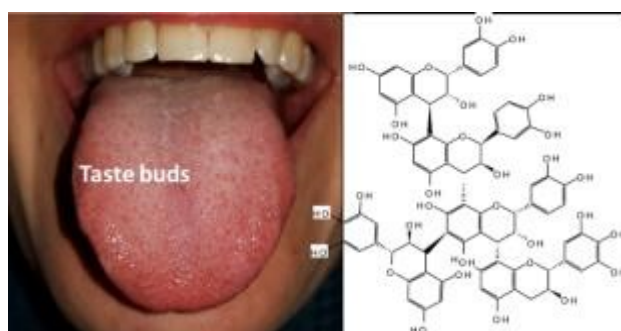


Fig. 1. The tongue is a “sensitive instrument” to detect tannic acids for example in red wine

METHODS

We collected substrate samples from the upper 20cm peat layer and fresh roots of dominant vascular plants and mosses (i.e., the peat parent material) from five formerly drained and rewetted sites, and from five more pristine sites of NE Germany and NW Poland. We determined total phenolic contents in these samples, and quantified hydrolysable and condensed tannic substances. Polyphenolics from less decomposed peat and living roots were served as an internal standard for polyphenol analysis and to run enzyme inhibition tests. This natural standard material proved to hold an advantage over chemically pure, commercial standards cyanidin chloride and tannic acid, as quantification with these phases led to a considerable underestimation (up to 90%) of polyphenolic concentrations in peat soils.

RESULTS and DISCUSSION

As hypothesised, we found that highly degraded peat contained eight times lower levels of total polyphenolics and 50 times lower levels of condensed tannins than less decomposed peat (Tab. 1). In addition, we found that polyphenol contents of plant tissue were strongly different between plant species, with highest contents in roots of *Carex appropinquata* that were more than 10-fold higher than *Sphagnum* spp. (450 vs. 39 mg/g dry mass). Despite these differences, enzyme activities and peat degradation state were not significantly correlated, indicating no simple linear relationship between polyphenolic contents and microbial activity.

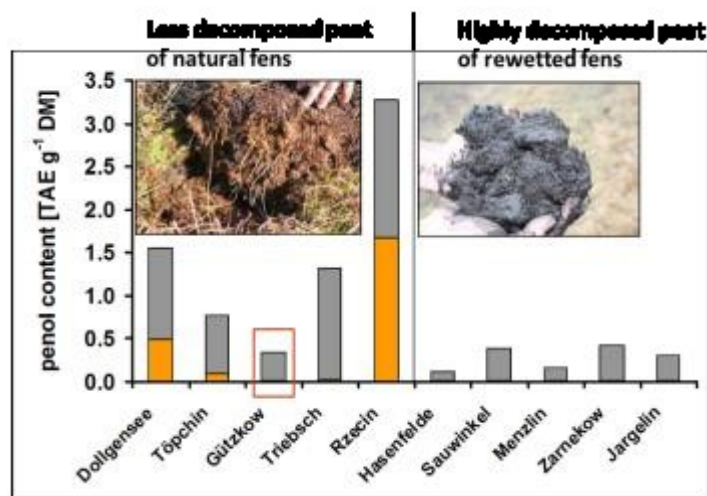


Fig. 2. Higher polyphenol contents in less decomposed peat (exception Gützkow) and negligible amount of condensed tannins (orange colour) in highly decomposed peat

ACKNOWLEDGEMENTS

The study was supported by the Department of Environment of Mecklenburg-Vorpommern and by the European Agriculture Guidance and the Guarantee Fund (EAGGF).

D7 - The differences of peat and water quality of degraded and natural peatlands in northern and central Europe with special emphasis on phosphorus, nitrogen and carbon

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INTRODUCTION

The eutrophication of water bodies and the accompanied loss of biodiversity is a serious problem in most regions of Europe due to non-point source phosphorus and nitrogen pollution from intense agricultural land use. One strategy to improve water quality as required by the EU Water Framework Directive is to restore natural nutrient sinks like peatlands. Originally, they covered about 495,000 km² of Europe, or 5% of the total land area. In order to restore their functions as sinks for nutrients and carbon as well as habitats for rare plant and animal species, degraded peatlands have been rewetted in many European countries. However, due to non-reversible changes of peat characteristics and substantial soil subsidence, many rewetted peatlands become shallow lakes (average water depth of less than 1 m). The high nutrient availability promoted by highly degraded peat soils in these newly formed ecosystems then favours the fast establishment of a small number of helophytes while the return of lost peat forming target species like low sedges and bryophytes could be delayed for decades. In order to achieve restoration objectives, it is therefore essential to understand how peatland type (bog or fen) but also the degradation status and legacy influence the temporal and spatial variability of peat and water quality. In turn, these differences in peat and water quality can be used to try to explain the presence or absence of certain vegetation patterns.

METHODS

From 1999 to 2016 we did a comprehensive field survey in more than 50 different degraded and natural peatlands of Germany, Poland, Estonia, Sweden, and the United Kingdom both in minerotrophic and ombrotrophic peatlands (Fig. 1). At each peatland site, at least three dialysis samplers were inserted into waterlogged upper soil layers (0-0.6 m) to obtain anoxic pore water samples. The samplers were set within a spatial distance of 5 to 10 m to determine the concentrations of different chemical species of phosphorus, nitrogen, and carbon (e.g. phosphate, ammonium and dissolved organic carbon). For a number of selected sites, we also recorded the seasonal changes or the changes over a post-rewetting period of 10 to 20 years. A detailed description of the preparation of the samplers, the sampling procedure, the chemical fixation of redox-

sensitive samples and the simulation of the P retention at the fen surface due to redox change and precipitation of Fe(III) hydroxides is given in Zak et al. (2004).



Fig. 1. An inundated degraded peatland formed after re-wetting in Germany (left) and a natural raised bog in Estonia with a dialysis sampler to sample anoxic pore water (right)

RESULTS and DISCUSSION

Peat characteristics of upper soil layers from ‘heavily drained peatlands’ and natural peatlands showed significant differences with lowest values for nutrient and metal contents observed in bogs. Long-term drainage and former agricultural use led to a loss of organic carbon due to peat oxidation and therefore to an enrichment of P and Fe with decreasing molar ratios of C/P and C/N in upper soil layers. Interestingly, pore water concentrations of dissolved substances were not generally higher in rewetted peatlands compared to natural peatlands. For example, the concentrations of soluble reactive phosphorus (SRP) in natural peatlands with high iron contents in soil and pore water were higher than 2 mg/L which was in the range of rewetted degraded peatlands. However, overall the concentrations of SRP, ammonium, and dissolved organic carbon in anoxic pore waters of the ‘heavily drained fens’ were on average 10 to 100 times higher compared to natural fens or bogs, whereas concentrations of dissolved substances in ‘weakly drained peatlands’ were only in some cases higher but not significantly different compared to natural peatlands. Another distinct difference was the level of dissolved organic carbon. Typically degraded sites had DOC concentration much higher than 100 mg/L and natural sites mostly below 50 mg/L. The large differences in vegetation patterns of sites under investigation were not always corresponding with pore water and soil chemistry. This implies that other factors than nutrient concentration like differences in hydrology might explain the presence or absence of certain plant species.

ACKNOWLEDGEMENTS

The study was supported by the state Mecklenburg-Vorpommern, the European Agriculture Guidance and the Guarantee Fund (EAGGF), and the Berlin Senate.

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B5 - Macrophytes in small lentic waterbodies between Adriatic, Alps and Pannonian lowland

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INTRODUCTION

Ponds and other small lentic waterbodies in three Slovenian regions were studied. These ecosystems are famous for their relatively big contribution in biodiversity conservation and many studies were done to reveal the relations with environmental factors (Zelnik et al. 2012; Svitok et al. 2015). These waterbodies became secondary habitat for Red list species which had lost a great share of their primary habitats. Slovenia is the meeting point of four floral provinces (Alpine, Mediterranean, Dinaric and Pannonian) and four hydrological ecoregions in terms of WFD which reflects also in high number of aquatic macrophytes. The aim of the study was to find out which of the studied environmental factors significantly correlated with plant species richness and which significantly influenced floristic composition of macrophyte community.

METHODS

We studied 48 small lentic waterbodies. First region was Karst plateau which rises above the Adriatic Sea (n=17), second was Alpine region at higher altitudes (n=16), while third region included western outskirts of Pannonian lowland (n=15). Macrophytes and environmental parameters were assessed according to standard methods. Species data and 15 environmental variables were analysed to find out the influence of selected factors on both species richness and composition of macrophyte communities.

RESULTS and DISCUSSION

Table 1. Variables which at least once significantly ($p < 0.05$) correlated with species richness

	Nr. of taxa			Nr. Of	
	All regions	Karst	Pannonia	Alps	RL species
average T	n.s.	n.s.	n.s.	n.s.	,446**
precipitation	n.s.	n.s.	n.s.	n.s.	-,604**
Altitude	n.s.	n.s.	n.s.	n.s.	-,662**
surface area	n.s.	,559**	n.s.	n.s.	n.s.
depth_max	n.s.	n.s.	,524**	n.s.	,316*
conductivity	n.s.	n.s.	n.s.	n.s.	,488**
land use	,284*	n.s.	n.s.	n.s.	,424**
substrate	,285*	n.s.	n.s.	n.s.	n.s.

In total 99 plant species were recorded, among them 19 species are on the Red List of vascular plants of Slovenia. Results of CCA revealed that four of the tested variables significantly influenced floristic composition. Altitude, mean annual precipitation,

shading of the ponds and humidity index together explained 15.4% of variability of macrophyte community. The ordination (Fig. 1) shows a clear differentiation of regions.

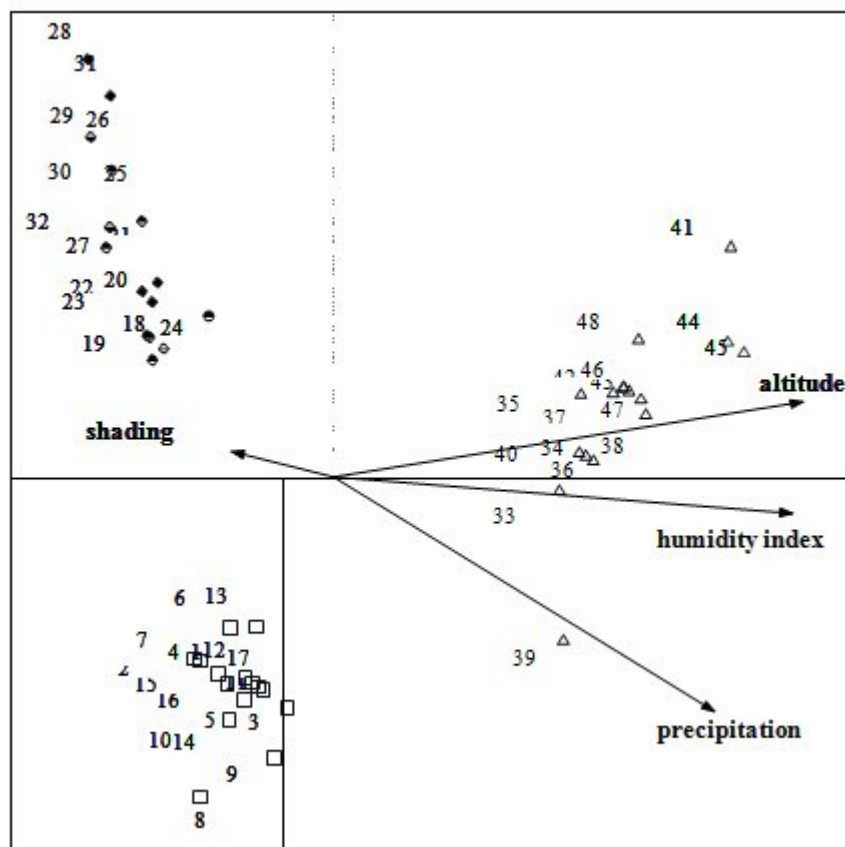


Fig. 1. Ordination based on CCA where samples are distributed along environmental gradients. Statistically significant variables are shown only. Squares - Karst; circles – Pannonian plain; triangles – Alps.

The natural land-use around ponds and loamy substrate are most important factors for species-richness in studied ponds (Tab. 1). In Karst region the species richness positively correlated with the surface area of the pond, while in Pannonian region this was noticed for the maximal depth. Both parameters represent the size of the waterbody which usually positively correlates with species number. In the case of the number of Red list species positive correlations were calculated with the average air temperature as well as the measured temperature of the water, conductivity, naturalness of the land use, while negative correlations were calculated with altitude and precipitation.

CONCLUSIONS

Proper management of ponds is needed to prevent the loss of species richness and Red list species. The measurements that are to be taken are maintenance of the depth of the water and low-intensity land use in the catchment area of the ponds, which would prevent eutrophication and accumulation of sediments accelerating the succession of ponds to marshes.

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Abstracts of poster communications

SWS PST 1 - Studenchishte wetland on the shore of Ohrid Lake: The process of its degradation studied by remote sensing

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INTRODUCTION

Studenchishte, a wetland area with natural marshes, fens and semi-natural wet meadows is the very last wetland of a previously extensive riparian fringe located on the shore of ancient Lake Ohrid, a UNESCO World Heritage Site, in the Ohrid-Prespa region of the Republic of Macedonia. This wetland has undergone man-caused gradual drying and degradation similar to that of other Macedonian wetlands over the last century. At present, only about 50 ha of wetland remain and they are facing total destruction for the purpose of tourism development and urbanization.

METHODS

This study describes the changes in land use and the consequences for the wetland size over the past 80 years using photographs and more particularly, over the past 45 years using satellite images (remote sensing, Landsat 5 & 8 images by ESA and USGS). These changes were related to the available reference data and the current general urban plan (GUP) of the city of Ohrid.

RESULTS and DISCUSSION

The broader Studenchishte area covers approximately 112 ha (according to the current GUP for the city of Ohrid) but significant remnants of the wetland are only covering 70 ha). As represented in Fig.1, the wetland area has suffered severe alterations of the land use over the last 45 years. Analysis by remote sensing has revealed that during periods of heavy rains and flooding such as in the spring 2010 and 2015, the wetland area covered with water was 24 ha. A similar figure was obtained by studying the satellite images relative to years of heavy snow on Galichica Mountain (located in the vicinity of the wetland and a natural boundary of Ohrid Lake) during the spring season and in association with melting of the snow.

CONCLUSIONS

Remote sensing methodology has proven a useful way to study the degradation of Studenchishte wetland over the past decades. The survival of the wetland requires the protection of the whole area, strong legislation to prohibit new building projects on the wetland and the beach along it, and efficient restoration of the land - now used for agriculture and certain facilities- towards marsh and fen.

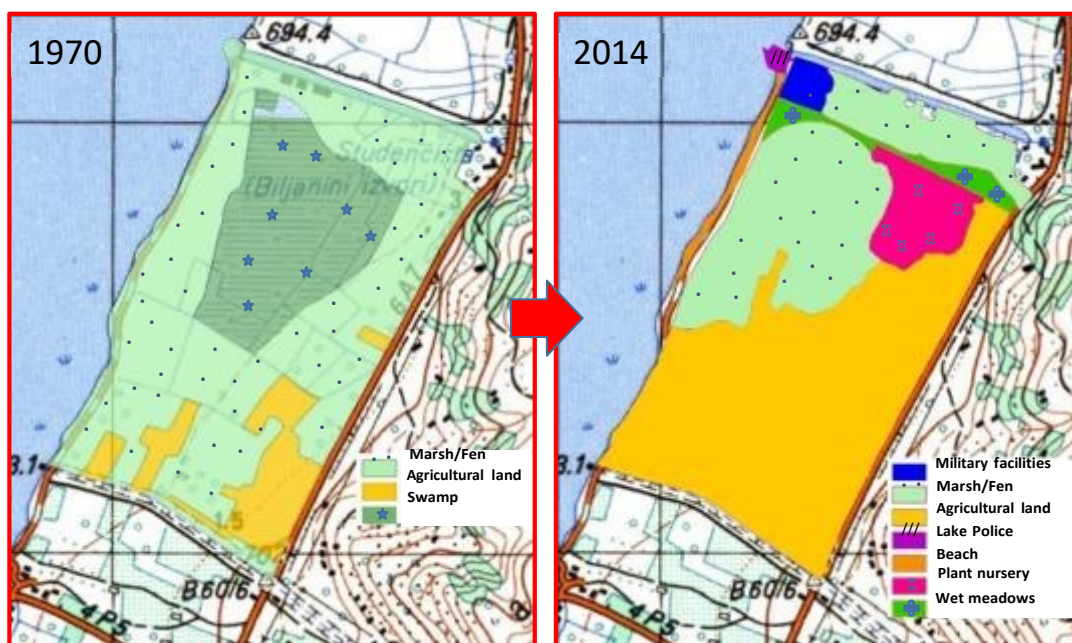


Fig.1. Urbanization of the southern section of Studenchishte area (Section I according to the current GUP) over the past 45 years- the map shows usage of the land in 1970 and in 2014

ACKNOWLEDGEMENTS

The authors acknowledge all Ohrid SOS members and the experts - authors of the “Integrated Study about the condition of the remaining of Studenchishte Marsh”.

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SWS PST 2 - Stress tolerance in pre-conditioned plant populations through Pulse Amplitude Modulated (PAM)

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Different plant populations of the same species can be exposed to different environmental stresses which can precondition plant tolerance and resistance responses to other stresses. Thus, it is important to identify and assess functional traits in which environmental variability has a significant role in how the species respond to global and local change. The effects of abiotic and biotic stresses in plants are generally revealed by chlorophyll fluorescence analysis, a non-invasive measurement of photosystem II (PSII) activity. Pulse-amplitude modulated (PAM) fluorometry is one of the most common techniques used to study the induction and quenching of chlorophyll fluorescence in physiological studies. Using PAM to measure heat-stress induced changes in two halophytes populations with different pre-conditioning histories (heavy metal contaminated are versus non-contaminated environment) showed significant physiological variances in the PSII photochemistry regarding response and resistance to the same stress which shows intraspecific variation probably due to environmental variation. The finds were supported by biochemical analysis of the leaf fatty acid composition presenting a significant variance in linoleic acid and linolenic acid concentration and between the ratio of unsaturated to saturated fatty acids which expresses the same variability between populations. In the near future, it will be important to increase long-term studies on natural populations in order to understand plant response to environmental factor including climate change.

SWS PST 3 - Duckweed (*Lemna minor* L.) – An experimental plant for phytoremediation of dairy effluent

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INTRODUCTION

The small and medium dairy factories generate effluents that represent a significant environmental impact, especially when they are located near ecologically sensitive areas. From an environmental point of view, dairy effluents pose a considerable risk of eutrophication in slow moving receiving waters. Dairy effluents exhibit high COD and BOD values due to lactose and fat contents, leading to a high consumption of dissolved oxygen in water. Furthermore, the high values of ammonium nitrogen (NH₄⁺-N) can have toxic effects on aquatic life. Such effluents may significantly burden the local municipal sewage treatment systems with organic matter. Dairy wastewaters are generally treated very easily using various conventional treatment methods. The existing conventional technologies are not appropriate for small and medium-scale cheese making plants and, in most of cases, wastewaters are discharged stored without any treatment. Phytoremediation is eco-friendly technique, which uses plants as well as microorganisms to remove or render harmless pollutants from contaminated water. The objective of the present study is to test potential of aquatic plants as an alternative and cost effective treatment. Fast growth rate and easy harvest potential made duckweed (*Lemna minor* L.) a good experimental plant species for phytoremediation activities, and also the fact that the species thrives in water rich in nitrogen and other nutrients.

METHODS

Lemna minor L. plants used in this study were collected from botanic garden Ptuj, Slovenia and grown in the tank with the addition of nutrients in long day conditions (16 hours light and 8 hours dark) at a temperature of 24±1°C. The plants were grown under white fluorescent lamps (90 µEm-2s-1). Cheese whey effluents were collected from small process factory located on the premises of Karlovac University of Applied Sciences (Department of Food Processing Technology). Physico-chemical parameters of the effluents before and after the phytoremediation treatment were analyzed: pH, conductivity, density, TDS, BOD, COD, chloride, oil/greens, total nitrogen, total phosphorus, and calcium. UV/VIS spectrophotometric determination of chlorophyll A, B and total carotenoid contents were performed. The amount of chlorophyll in plant leaves was calculated by the formula according to Maclachalam and Zalik (1963). Effluent sample was diluted with 30 % tap water before treatment. For the experiment, 50 healthy duckweed colonies with 2-3 fronds were placed in the glass aquarium loaded with 5 L of diluted cheese whey wastewater. Experiments were performed in triplicate for 7 days. For each experimental set, two controls were maintained: tap water with *Lemna minor* L. and raw effluent without plants.

RESULTS AND DISCUSSION

The COD/BOD ratio equal to 0.69 indicates easily degradable substances in cheese whey wastewater. Since we determined that COD value of cheese whey was too high for aquatic plants to tolerate organic loading (above 1000 mg/dm³), sample effluent was diluted with tap water in ratio 1:30 before treatment. Fat substances represented difficulty for *Lemna minor* L. plants in no diluted systems, because plants were completely submerged into fat. Physico-chemical analyses of cheese whey wastewater, before and after 7 days of phytoremediation process implementation, showed enhancement in water quality: pH value increased from 5.63 to 7.07, COD value decreased to total of 148 mg/l, while dissolved oxygen increased from

1.94 mg/L to 7.22 mg/l. No significant differences in the amount of photosynthetic pigments was found after 7-day exposure to cheese whey wastewater.

CONCLUSIONS

Study indicated phytoremediation ability of *Lemna minor* L. for treatment of cheese whey wastewater. It was observed that duckweed played significant role in COD removal from dairy wastewater. We recorded 93.17% reduction in COD for treatment of cheese whey wastewater in seven days. However, treated effluent must be diluted or pre-treated to meet aquatic plant requirements.

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SWS PST 4 - Development of forshore mires in humic lakes of NE Poland

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INTRODUCTION

Humic (dystrophic) lakes are characterized by catchments covered with peat and/or overgrown by coniferous forests, the presence of *Sphagnum* carpets in the vicinity of water bodies, the high content of humic substances (HS), low calcium content, low pH (4.5-6.0), small algal biomass, poor taxonomic biodiversity, higher respiration than primary production and dy-type sediments (Brönmark and Hansson, 2005).

Humic lakes are typical of the boreal zone (Ojala and Salonen, 2001). In northeastern Poland they occur in the Wigry National Park (WNP), where climate and vegetation cover just alike this territory to the Scandinavian conditions.

These ecosystems have been studied in detail using hydrobiological methods, which have confirmed their dystrophic status (Górniak et al., 1999). Less attention, however, has been focused on their evolution. To complement these deficiencies of knowledge we aimed in this study: (i) to reconstruct the lakeside vegetation and habitat conditions in the vicinity of the studied water bodies; (ii) to identify developmental tendencies of humic lakes.

METHODS

Material for the study was collected from the lakesides of three dystrophic lakes, using a Russian sampler (50 cm long and 8 cm in diameter). The lengths of the cores were as follow: from Lake Suchar IV (LSIV) – 370 cm, from Lake Sucharek (LSch) – 170 cm, and from Lake Widne (LW) – 90 cm. The cores were divided into segments of 5 cm.

In our study we used analysis of macrofossil plant remains in peat, determination of peat decomposition degree, and geochemical analyses of peat (fixing of C/N parameter), as well as radiocarbon datings of selected sediment samples to determine the age of lake developmental phases.

RESULTS and DISCUSSION

We stated that three studied humic lakes originated in the different periods of the Holocene. The age of bottom sediments was 5,000-4,900 cal BP in LSIV (the Subboreal period), 9,880-9,670 cal BP in LSch (the Boreal period), and 8615-8505 cal BP in LW (the Atlantic period). Such diversity of age was recognised also for the other humic lakes of Wigry National Park. Some of them developed even in the Late Glacial (Drzymulska et al., 2015).

In total, remains of 31 plant taxa were recognised in sediments from Lake Suchar IV, 28 – from Lake Sucharek, and 27 – from Lake Widne. Basing on the botanical composition of peat, its units were named. Two peat units identified in the LSIV profile were *Sphagnum* peat, and *Sphagnum* peat with *Pinus*. Mean value C/N was 23,01. Three peat units described in the LSch profile were Cariceto-Phragmitetum peat, Cariceto-Phragmitetum peat with wood, and *Carex*-

Sphagnum peat. Mean value of C/N was 30,66. Whereas, in the LW profile poor fen *Sphagnum* peat, Cariceto-Phragmitetum peat, and *Carex-Sphagnum* peat were noted. Mean value of C/N was 66,43. The C/N parameter is used to determine the domination of autogenic or allogenic sources of organic matter in sediments. The C/N ratio for aquatic plants, phytoplankton and zooplankton is 10 or below, whereas that for terrestrial plants exceeds 10 and can be as high as 45–50 (Meyers, 1994; Ji et al., 2005). The sediments from the LW core comprise fen peat (sedge-reed peat of dense consistency formed by peat mosses, sedges, reed and other emergent plants). The highest value of the C/N ratio in the profiles studied was noted in the LW core, and this suggests a higher proportion of terrestrial organic matter in the sediments, especially those of reedswamp origin.

The subfossil plant community succession differed in each of the lake shores studied. Three different developmental tendencies of studied water bodies were described: towards bog vegetation in the marginal zone (in LSIV), what seems to typical for humic lake, towards transitional mire vegetation (in LSch), and towards fen vegetation (in LW). Characteristic features of studied foreshores were given in Table 1.

Table 1. Characteristic of studied foreshores

Foreshore of Peat unit		Age of sediments	Subfossil vegetation
Lake Suchar	<i>Sphagnum</i> peat	?	
IV			
	<i>Sphagnum</i> peat with <i>Pinus</i>	after 5000-4900 cal. BP	peat moss communities of bog
Lake Sucharek	<i>Carex-Sphagnum</i> peat	since 2800-2580 cal. BP	communities of moderately poor fen
	Cariceto-Phragmitetum peats with wood	since 8400-8300 cal. BP	
			reedswamp vegetation of rich fen
	Cariceto-Phragmitetum peat	after 9880-9670 cal. BP	
Lake Widne	poor fen <i>Sphagnum</i> peat	since 1955-1957 cal. AD	sedge-peat moss communities of moderately rich fen
	Cariceto-Phragmitetum peat?		reedswamp vegetation
	<i>Carex-Sphagnum</i> peat	since 8615-8505 cal. BP	sedge-peat moss communities of moderately rich fen

ACKNOWLEDGEMENTS

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SWS PST 5 - Bird conservation in Lesser Prespa Lake: Benefiting local communities and building a climate change resilient ecosystem. LIFE+ project (2016-2021) - Experiment management and restoration of reedbeds for waterbirds

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Prespa National Park (Greece) is important for biodiversity including internationally important wetland ecosystems surrounding two connected lakes. The lakes host 23 fish species, including eight endemics, and the park contains 11 amphibians, 21 reptile and 60 mammal species. Avifauna includes 272 bird species, of which 164 breed and 88 are listed in Annex I of the Birds Directive. The park hosts the largest breeding colonies in the world of the Dalmatian pelican (1150-1500 pairs) and the great white pelican, as well as over 1 000 pairs of the pygmy cormorant. Conversion of its wetland habitats into agricultural land and surface irrigation have taken their toll and degraded the lake's ecosystem, leading to shrinkage of wetland areas. But recent conservation efforts have shown that conservation management (water level and vegetation management) can benefit the waterbird populations.

The overall project objective of the LIFE Prespa Waterbirds is to improve the conservation status of target bird species in the area by addressing the following major threats: (1) limited foraging areas for wading birds;(2) obstruction by reed-beds of the potential foraging sites and spawning of fish; 3) reedbed wildfires causing low breeding output of water birds and (4) the potentially devastating impact of avian flu on pelicans meta-populations.

The recent encroachment of *Typha angustifolia* in *Phragmites* reedbeds is a major concern for the conservation of breeding populations of both species of pelicans which establish their nests only on *Phragmites* stands. Several hypotheses are tested for explaining the causes of change in dominant species including eutrophication resulting from agriculture, wild fires, hydrology and the interactions between these factors. Experimental management will be implemented to prevent the expansion of wild fires, increase the surface area of wet meadows and stop or reverse the expansion of *Typha* in reedbeds.

SWS PST 6 - Adsorption of Linear Alkylbenzene Sulfonates on Wetland Soils obtained from Karlovac area (Croatia)

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INTRODUCTION

Surfactants such as linear alkylbenzene sulfonates (LAS) are widely used in household and industrial products, and they have different behaviour and fate in the environment. Although LAS degrades rapidly in plant-soil systems, due to its adsorption ability on soil, its potential contamination of wetland cannot be ignored. Adsorption of LAS onto soil depends on many factors such as its physiochemical properties, soil nature and environmental parameters and have a significant influence on the degradation of the surfactant in the environment (Oliver-Rodríguez et al., 2015). The main objective of this work is to study the behaviour of LAS adsorption on soils collected from different wetland area of Karlovac through laboratory experiments, to evaluate some thermodynamic parameters important for sorption characteristic of investigated soils.

METHODS

Four soils were collected and studied for the adsorption behaviour of LAS. Three of them are collected from wetlands that are located in the area of Karlovac, namely Dubovac, Lušćić and Šumbar, while one soil is collected from the backwater of river Korana. All soil samples were collected from surface (about 10 cm in depth) and dried to constant weight at 85°C. The concentrations of the anionic surfactants (LAS) were determined by colorimetric method using Methylene Blue as described previously (Zubeta et al. 2008). The absorbance of the Methylene Blue complex was measured with a spectrophotometer DR2800 Hach- Lange. For adsorption equilibrium isotherms, soil samples of 1.5 g were mixed with 30 mL water solutions of different total LAS concentration: 2, 5, 10, 15 and 20 mg L⁻¹, in duplicate. All mixtures were shaken for 10 minutes and left at stationary state for the next 24 h. They were then centrifuged at 3500 rpm for 30 min and the liquid phase was removed. All experiments were performed in a temperature controlled laboratory, at 20°C. pH and carbonate content of soils were determined, too.

RESULTS AND DISCUSSION

LAS adsorption on investigated wetland soils can be described by Freundlich adsorption isotherm, which can be expressed as:

$$\ln x / m = 1 / n \ln c + \ln K$$

where x/m is the adsorption amount of LAS on soil (mg kg⁻¹), c is the equilibrium concentration of LAS in solution (mg L⁻¹), K and n are adsorption constants. The obtained characteristics of the soils are given in Table 1. The values of adsorption constant K_{ads} of LAS, which represents the equilibrium constant for the adsorption/desorption process of the LAS molecules on the soil surfaces, indicated on strength of adsorption.

Kads values for two wetland soils (Lušćić and Šumbar) were essentially similar to each other and quite different to those of soil obtained from backwater of river Korana (only 332.1 L kg⁻¹). The highest value of Kads was determined on soil from Dubovac. These differences can be explained on the basis that LAS adsorption on soils is dependent on pH and with decreasing pH value adsorption is stronger, due to a higher positive charge of colloidal surfaces (Inoue et al., 1978). Kads value can be related to the standard Gibbs free energy of adsorption (ΔG) which in this work are ranging between -14.14 kJ mol⁻¹ and -21.18 kJ mol⁻¹. These values indicate that the adsorption mechanism of LAS on wetland soils at the studied temperature has electrostatic character, since the values of ΔG up to approximately -20 kJ mol⁻¹ are consistent with typical physical adsorption (Marchesi et al., 1991).

Table 1. Wetland soils parameters obtained at 20°C in laboratory experiments.

Soil sample	pH	% CaCO ₃	Kads (L kg ⁻¹)	ΔG (kJ mol ⁻¹)
Korana	8.40	28.14	332.1	-14.14
Dubovac	6.41	4.75	5973.1	-21.18
Lušćić	6.96	16.17	1805.0	-18.07
Šumbar	6.61	18.50	1257.2	-17.38

CONCLUSIONS

The adsorption of LAS on the investigated natural wetland soils is described by the Freundlich adsorption isotherm, indicating that the adsorption is quite weak, especially for soil collected from backwater of river Korana. Besides the fact that this soil has the highest pH value, this result is not surprising considering that it is a sandy soil. On the other hand, soil collected from Dubovac is a mixture of humus and sandy soil, and therefore the adsorption of LAS is the most pronounced. The values of ΔG confirm that LAS adsorption on soils involves a weak hydrophobic interaction (physisorption) with soil/mineral particles.

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SWS PST 7 - The Waterharmonica: (re)use of treated waste water through natural processes also in the Algarve, Portugal?

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INTRODUCTION

During the 1st Annual Meeting of the Society of Wetland Scientists – Europe “Integrating our approaches to Wetland Science” in Bangor, Wales, UK in 2006 we presented two posters on the “Waterharmonica concept: Trophic webs from discharges: nature enhancement through the Waterharmonica concept” and “Sludge particles as food source for *Daphnia*”. Due time the Waterharmonica became an even in national policy accepted concept in The Netherlands, with increasing global interest, especially in Spain (Sala and Kampf, 2014).

In the same period huge efforts have been made in the Algarve to construct over 800,000 population equivalent waste water treatment capacity. Most discharge, as happens elsewhere in coastal tourist areas in the Mediterranean is direct or indirect into the Atlantic ocean. This means that without water reuse yearly 50,000,000 m³ water is directed from land into the ocean, taken out of the “fresh water cycle”.

Actually, well treated waste water is not a waste anymore, the waste has largely, to a large extent been taken out of the water. The effluent turned into a very clear, but still ‘dead water’, clear but with loose bacteria and sludge flocs. It is good to realise that the effluent basically comes from drinking water, a very pure clean water. During the process of potable water production all forms of natural life are eliminated. Waste water treatment added only low forms of life, and energy. It is thus needed to turn this effluent into an attractive and clear water. Is it possible to apply the Waterharmonica ideas in the Algarve. Is it affordable and what are the benefits?

SUSTAINABLE WATER REUSE IN PORTUGAL

Portugal, like most of Mediterranean EU member states, regularly experience severe water supply and demand imbalances, particularly in the summer months. Half of Portugal mainland suffers of water deficit. Tourism is a very important economic activity in Portugal and is pushing water demand particularly in regions suffering of water deficit, like the Algarve. Golf courses are an important tourist factor contributing to water demand rising. A number of golf courses are installed in tourist areas and need high amount of water for irrigation. Water reuse is a very important management strategy in situations of water scarcity. Portugal badly needs to include treated wastewater as a dependable water in the nation water resources management. Safe water reuse requires guidelines. This standard presents guidelines on: water quality, irrigation practice, management of environmental impacts, protection of public and

animal health and aspects of control and monitoring (fully cited from Marecos do Monte, 2014).

NATURAL PROCESSES FOR “UPGRADING” TREATED WASTEWATER

Upgrading of well treated waste water in natural constructed wetland systems is not new. We found descriptions in English like: natural systems for wastewater reclamation, enhancement marshes, wetland treatment systems, constructed treatment processes, natural reclamation systems, effluent polishing in constructed wetlands, wetland to accept tertiary treated wastewater, constructed wetlands for secondary effluent treatment and water reuse, reclaimed water potential for aquatic ecosystem restoration or recreation, free water surface wetlands for tertiary wastewater treatment, constructed surface flow wetlands treating effluent from wastewater treatment plants, "nature-based solutions for water pollution control", etc.

Plus –in other languages- as an example: Nachklärteiche, spillvattenvatmarker, efterpolering av spillvatten, moerassystemen. For the moment we call these “Waterharmonica-alikes”, in the hope and expectation that the simple, fancy, short, catchy, strange name Waterharmonica will be accepted by the SWS-members, or even will become a Waterharmonica.

THE WATERHARMONICA, SINCE 2006

Calling all of the above processes “Waterharmonica” made the idea of using “constructed nature” an accepted natural constructed wetlands application for water management in The Netherlands, see www.waterharmonica.nl for backgrounds, publications and reports. The process became a part of Dutch national water policy, awarded with the Water Innovation Award 2016 in the Category *Clean Water*.



Fig. 1. Waterharmonica's in The Netherlands (www.climatescan.nl)

Simply called Waterharmonica in The Netherlands:

The Waterharmonica is nowadays an accepted, tailor made innovation in water management in The Netherlands.

The Waterharmonica-alikes can be found all over the world.

Please come to the poster/interactive digital knowledge exchange session to bring in your own experiences and ideas.

Up to now fifteen full scale Waterharmonica's for ecological upgrading are in operation with capacities of 1,000 – 40,000 m³ treated waste water per day, with five more under design in The Netherlands. The first ones were aiming on producing nutrient removal, buffering water and supply water for agriculture. Most of the recent

Waterharmonica's are focusing on creating natural values, fish spawning areas and migration opportunities and on natural processes for water reuse as recreational waters. See figures 1 and 2.



Fig. 2. Variation of Waterharmonica's in The Netherlands

WHY A WATERHARMONICA?

Waterharmonica's are tailor-made systems of (Daphnia) ponds, wetlands, wet meadows, shallow or deeper reed beds, fish spawning areas, fish ponds, wet forest, etc. to convert (well) treated waste water into a living, ecological sound surface water. Possible benefits are water storage, blue/green buffers, nature values, recreation, ecosystem services and a source of water and life.

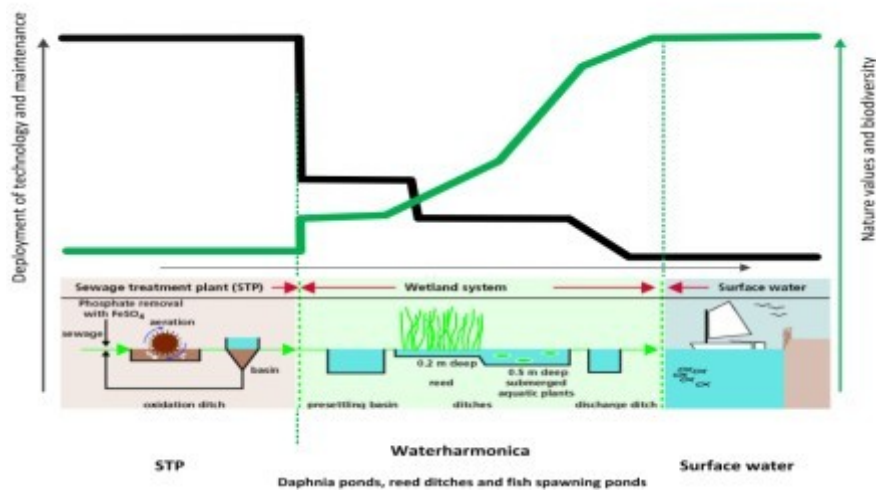


Fig. 3 The Waterharmonica: a natural link between WWTP and the environment

In figure 3 the Waterharmonica is depicted as a link between the technical part of the Water cycle (the Water chain) and the surface water, the Water system. The black line gives the 'deployment of technology and maintenance' (cost). The green line 'nature values and biodiversity', or even better biological richness ("biorichness, a wealth of

natural life can with even limited biodiversity can be very attractive to, though less appreciated in scientific ecology). A Waterharmonica provides a ‘soft landing’ of the effluent in the environment. In some cases the green line at the end of the Waterharmonica will rise higher than the surroundings, this is the case in f.e. the Waterharmonica’s Grou and Empuriabrava.

When planning a Waterharmonica a checklist contains bullets like: is enough space available at and around the STP?; meeting the existing discharge requirements: can a Waterharmonica prevent the possible exceedance of N and P standards and/or suspended solids?; requirements based on the EU-WFD objectives, both water quality and layout, part of the ecological corridor; required biological disinfection to meet bathing water requirements, both for ‘official bathing water according to EU-WFD regulations’ and water where ‘people swim’; storage and buffering of water; nature objectives; recreational use; reuse; based on the reuse as city, nature, agricultural or industrial water; government levy for the discharge of effluent, etc..

A quick-scan in the province of Friesland in the north of the Netherlands pointed out that most of the 28 WTP’s of the water authority from the point of view of improving the effluent quality a Waterharmonica is an appropriate solution. But moreover the value is basically a combination of EU-WFD requirements, water system improvement efforts, nature and recreation values and drought mitigation. It is a good method to tackle integral water issues with a low-tech, low-energy and cost-effective approach (Sala, Serra, Huguet et al, 2004). But it also means that in Friesland (and elsewhere!) Waterharmonica’s are only possible in a joint effort from many different stakeholders, like the province, municipalities, nature protection organisations as, the drinking water company, farmers and residents.

Cost for Waterharmonica’s vary very much, depending on size, and especially the simplicity or recreational services, creation or biological values, etc. As a rule of thumb, total cost of making a “living water” out of well treated wastewater cost around 5 Eurocent per m³ of treated water, with a bandwidth between 2 and 12 cents, comparable with cost of sand filtration alone.

MAPPING WATERHARMONICA’S

The map above has been made with the international open source tool Climatescan, a mapping for all kind of green initiatives (www.climatescan.nl): roll-out menu: *Waterharmonica: biological link to change (well) treated waste water into usable surface water*. More than 1000 green projects are listed by now, see for information and backgrounds Boogaard et al, 2017).

The basic, background information can be found on the *Google maps Waterharmonica application*: www.google.com/maps/d/edit?mid=1ldUqKDoICusiUcbJcLuJgr5zmjw. It lists not only the Dutch Waterharmonica’s but also the Waterharmonica-alikes. Quite a few of these came from Fabio Masi, who kindly made a dataset of Global Wetland Technology available for us. The Google application gives the possibility to propose your Waterharmonica-alike to be a Waterharmonica. To do that, please get in touch with the first author.

WATERHARMONICA’S IN THE ALGARVE?

Since 2005 the Algarve made a huge progress in waste water treatment, eight WWTP's with a total capacity of over 800,000 population equivalent (PE) will be constructed at the end of 2017, amazing progress in a short period (table 1). The total investment will be over 70 million Euro. It is however good to realize that waste water not only has disadvantages. Once it was drinking water, plus rain water. The volume of treated waste water will be more than 100,000 m³/day, ready to be used again, ready for an upgrade in a Waterharmonica.

Table 1. Waste water treatment plants in the Algarve (Águas do Algarve, SA)
Data from www.postal.pt/2015/02/faro-olhao-portimao-ganhama-novas-etars/

ETAR / WWTP	Year	Capacity	Investment	Waterharmonica possible?				
		PE	Million Euro	1	2	3	4	5
Lagos	2005	138,000	?	++	+	+	+	0
Companheira	2017	140,000	11.6	++	++	++	+	0
Boavista	2007	33,180	5.0	-	--	+	+	?
Vale Faro	2005	130,000	4.2	--	--	+	--	--
Vilamoura	2006	138,000	9.3	++	--	++	++	++ ?
Faro Noroeste	2009	44,350	9.7	++	++	++	++	0
Faro/Olhao	2017	140,000	14.5	++	++	++	++	0
Almargem	2007	48,200	5.5	++	+	+	+	0

Notes to the table:

1	Water Framework Directive / Wetland restauration	++'	very attractive
2	Fish spawning	+'	attractive
3	Natural values / landscaping / birds / recreational values	0	indifferent
4	Effluent polishing, nutrient removal, disinfection	-'	not important
5	Water buffering	--'	why?

Google mapping is used to assess feasible Waterharmonica possibilities in the Algarve. For the eight WWTP's a rough estimate has been made of the possible benefits of a Waterharmonica, for aspects like the European Water Framework Directive, wetland restoration, possible fish spawning (including fresh water / salt water gradients), natural values, landscaping, birds (bird watching), recreational values, effluent polishing, nutrient removal, disinfection and the need for temporary water buffering. As an illustration for a Waterharmonica with high natural values and a fish spawning area based on the revived treated wastewater, even close to the conference venue:

WWTP Faro Noroeste, figure 4.



Fig. 4. ETAR de Faro Noroeste Sewage treatment plant (N 37.018°, W -7.957°)

CONCLUSIONS

Natural water reuse in Waterharmonica's in Portugal, and in particular the Algarve, will be feasible and will also not be very different from the Costa Brava in Spain. The results from the Waterharmonica Empuriabrava will be useful (Mujeriego, Lagostera, Sala et al, 2011, Sala and Kampf, 2014). Most WWTP's in the Algarve are situated in quite natural settings, that means that most Waterharmonica's could be low to very low loaded, aimed on natural values. That implies hydraulic loadings less than 0.1 m/day, or 0.7 – 2.5 m² per population equivalent. This means sizes for the plants of around 140,000 PE between 10 and 35 ha, when all treated wastewater goes through Waterharmonica's. The smaller plants could be between 2 and 10 ha, though for instance for Faro Noroeste size could be better determined by “the chance”: how much fresh / saltwater can be created for fish spawning area of attractive nature. Actually the existing ponds are already around 10 ha, only “restyling” into a Waterharmonica could be enough. The WWTP Vilamoura is situated adjacent to a Océanico golf course. A part of the effluent could be “upgraded” as in the Dutch Waterharmonica Klaterwater (leisure centre De Efteling). See for more backgrounds Kampf and Boomen, 2013.

SOURCES,

Project site: www.waterharmonica.nl

Waterharmonica 1st SWS Europe in Bangor, Wales:
www.waterharmonica.nl/publikaties/2006_Bangor_Wales/bangor.htm

Waterharmonicas in the Netherlands (1996-2012):

stowa.nl/upload/publicaties/STOWA%202013%2008%20LR.pdf

Netherlands Water Innovation award 2016:

www.waterinnovatieprijs.nl/project2016/s-c-h-o-o-n/

Waterharmonica mapping:

www.google.com/maps/d/edit?mid=1ldUqKDoICusiUcbJcLuJgr5zmjw

www.climatescan.nl

Waste water treatment in the Algarve (Águas do Algarve, SA): www.aguasdoalgarve.pt

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SWS PST 8 - Cyanobacteria in small water bodies: the effect of habitat and abiotic factors

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INTRODUCTION

Expanding and escalating blooms of cyanobacteria have become a key problem in ecological analyses. Cyanobacteria are not only a threat to the whole ecosystem but on a smaller scale they interfere with the relationships between all organisms creating a food web (Ger et al, 2014; Ger et al., 2016). Because cyanobacteria, which occur in almost each terrestrial and aquatic environment and are an important component of many biological monitoring programmes for the assessment of water quality, they can also serve as a valid instrument in the ecological analyses of small water bodies. Therefore, we have assumed that their response to particular environmental features will help us to understand their role in the functioning of ponds; ecosystems that suffer from a variety of types of human-impact intensification.

METHODS

The study included 54 small water bodies located within field (28) and forest (26) catchment area. Three habitats, differing in the level of complexity (homogenic open water area and two heterogenic zones within macrophytes: helophytes and elodeids) were examined with reference to environmental factors, including abiotic features (physical parameters of water) and biotic parameters such as the presence of various feeding groups of zooplankton. The response of cyanobacterial taxa to environmental conditions was analysed using the multivariate statistical program package CANOCO version 4.5 (ter Braak and Smilauer, 2001).

RESULTS and DISCUSSION

There were 104 cyanobacteria taxa identified in total. Analysing the distribution of particular species we observed that cyanobacteria were selectively attributed to stations located within the open water zone and among elodeids, while no close affinity was found for helophytes (Fig. 1).

Most of the cyanobacteria taxa that occurred in our ponds with high frequency and/or most abundantly were colonial forms (e.g. *Planktothrix agardhii*, *Aphanizomenon flos-aquae*, *A. gracile*, *Microcystis aeruginosa*, *M. wesenbergii*).

A great impact of nitrogen forms (N-NO₃, N-NH₄) as well as TRP, pH and conductivity was also found on the occurrence of certain species, as was also demonstrated by other researchers (e.g. Pelechata et al., 2016; Grabowska and Mazur-Marzec, 2016). At the same time we observed that the presence of zooplankton was of minor importance.

The results of this study contribute to a widening of knowledge on the functioning of small water bodies and also the assessment of their ecological state. Weak relationships between cyanobacteria and zooplankton indicate that these microalgae usually create a poor quality food for zooplankton grazers. The results of this study may also lead to the protection and maintenance of these valuable ecosystems, which are systematically disappearing from the aquatic landscape.

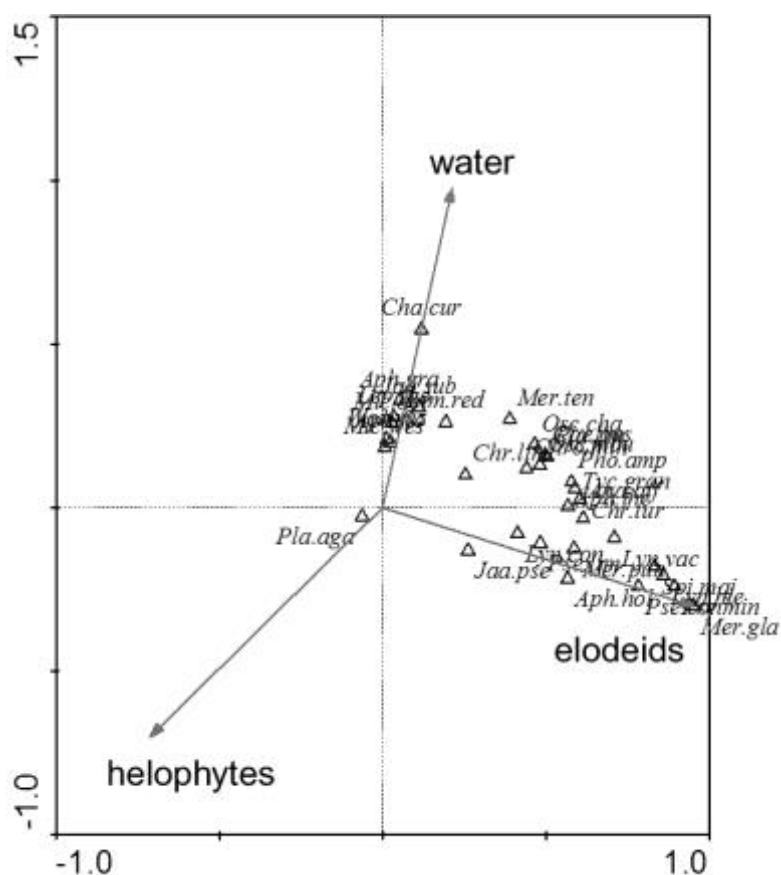


Fig. 1. Canonical correspondence analysis (CCA): ordination diagram of the distribution of the dominant cyanobacteria species in relation to habitats (the open water zone, helophytes, elodeids)

CONCLUSIONS

The study revealed that cyanobacteria in small water bodies can be treated as a valuable indicator of important ecosystem conditions, especially abiotic factors.

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SWS PST 9 - Restoring Wetlands in Kampinos National Park – Chances and Challenges

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Kampinos National Park (Central Poland) is characterized by the contrary presence of inland sand dunes and wetland habitats. The latter are threatened due to drainage activities from the 1800s to 1970s, and resulted in a groundwater level drop by 0.5 m. Thus, wetlands are gradually drying, resulting in a secondary succession in non-arboreal phytocenoses.

The LIFE KAMPINOS WETLANDS PL project aims to restore and maintain wetland habitats by (1) permanently increasing moisture content at the most valuable wetland sites, (2) halting secondary succession, (3) minimizing conflicting issues between local communities and conservation interests, and (4) elaborating benchmark solutions for water management on naturally valuable areas. These goals will be accomplished by technical actions such as constructing dykes and weirs, stopping groundwater from draining into a nearby channel, and removing old drainage ditches. Having commenced in 2013, measures have already taken place, which include the building of a digital elevation model, the purchase of 120 ha of private land in the park, a beaver population management plan, and developing guidelines for efficient weir usage for nature conservation goals.

Here, we discuss the project in detail, its current progress, and projections for its final outcome. By the end of the project, the soil moisture content of an area of ca. 6000 ha is expected to have increased as a result of this project. At the same time, the range size of NATURA 2000 species and habitats (e.g. riparian forests, *91E0), oak-hornbeam forests (Tilio-Carponetum, 9170), lowland hay meadows (Arrhenatherion, 6510) and Molinia meadows (Molinion, 6410) are believed to increase. Priority bird species that will benefit from the project are the Eurasian Bittern (*Botaurus stellaris*, *A021), Corn Crake (*Crex crex*, *A122) and the Lesser Spotted Eagle (*Aquila pomarina*, *A089). So far, the limiting factors to this project are changing laws regarding the purchase of land as well as time-constraints due to seasonality and waiting-time for permits, however all constraints could be solved.

SWS PST 10 - Water fluxes and nutrients loading: A tool for wetland restoration in Albufera of Valencia

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INTRODUCTION

The National Park of the Albufera is an important Iberian and Mediterranean coastal wetland (Valencia, Spain). The wetland (223 km²) is between the Turia and Júcar rivers, and mainly composed by paddy fields (Soria, 2006). It has also the largest Iberian coastal lagoon (23 km² and 1.2 m mean depth).

Since the 19th century, the Albufera lagoon has severe environmental impacts, from the agriculture and the demographic and industrial pressure in its catchment area. Overall, it has caused its progressive degradation and makes its management and conservation complex, because of the diversity of uses and economic policies (Romo *et al.*, 2005; 2013). It is relevant to mention that the area in which the Albufera and its basin are located is a Mediterranean climate zone, where droughts are frequent. It has been pointed out negative effects in the reduction of the renovation water rates of the lake by climate and agriculture (Romo *et al.*, 2008; Romo *et al.*, 2013). Renewal rates have a great potential for shallow lakes restoration (Hosper, 1998), which depends on the sustainable availability of good quality water. Thus, cyanobacteria blooms can be reduced in lakes by means of an increase in the water flushing (Romo *et al.*, 2013). Hosper (1998) suggested that winter, when algae growth is generally minimal and when more water is available, could be preferable for flushing, when it used as a restoration tool. In some Dutch lakes, an increase in water renewal rates have been successful to improve water quality, and some of these lakes were similar in size and cyanobacteria dominance to the Albufera.

The aim of this study is to evaluate the effect of an extra water input into the lake for improving its trophic state, by reducing the algal biomass and nutrient concentrations.

METHODS

In October and November 2015, the National Park of the Albufera and its lagoon received an extra water input from Tous reservoir, located in the Júcar river basin. The water input was the result of intensive rainfall (October 4th, 2015), as well as, an extra water volume of 11 Hm³ from the Júcar River. The water discharge into the lake began on November 4th and ended on November 20th, 2015. To assess the effect of these water inputs, water fluxes and nutrient loadings were measured in the main ditches of the Park, which output into the lake. Accordingly, some main limnological variables were also analysed to determine the effects and changes in the lake water quality.

RESULTS AND DISCUSSION

The results obtained in this work showed a clear dilution effect due to the water inputs, while renovation rates did not change due to water control for agriculture

purposes. An expecting decrease in the lake water conductivity was observed (from 1949 to 1875 $\mu\text{S}/\text{cm}$). The mean chlorophyll-a concentrations slightly were diluted without a significant change in levels (from 194 to 133 mg/m^3), while total phosphorus loading into the lake decreased from 120 to 80 kg/day . These effects were short and temporary and all variables returned to previous values once water discharges ceased. The effectiveness of punctual water inputs for improving the trophic state of the Albufera seems clearly fail without being supported by complementary restoration measures, for instance, by means of a nutrient reduction and an increase in the lake water renovation rates. The data obtained indicate that, although there are changes in different variables of the lake (such as nutrients, chlorophyll and conductivity) they return back in a few weeks to their initial values.

CONCLUSIONS

The most important measure to improve the state of the studied lake and wetland (ditches and rice fields) should be to reduce both nitrogen and phosphorus loadings. The high levels prevent any improvement in the trophic state of the lake or the aquatic ecosystems of the wetland. Water inputs without water renewal of the lake clearly failed as a restoration measure.

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SWS PST 11 - Different phenotypic traits among nine phylogeographic groups of *Phragmites australis* in a homogeneous environment

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INTRODUCTION

Heterogeneous environments play a key role both in selecting and evolving genetically determined phenotypic variation in plants. Various natural selection pressures like temperature, precipitation, daily radiation and competition give rise to multiple phenotypes of a single genotype in a natural environment – a phenomenon called phenotypic plasticity.

Phragmites australis (Cav.) Trin ex Steud., the common reed, is a cosmopolitan wetland plant with high genetic variability both within and between populations. In addition, phenotypic traits of *P. australis* are genotype-specific in different environments. The aim of this study was to compare the different phenotypic traits among nine phylogeographic groups of *P. australis*, especially the belowground traits which were limited known and We aimed at understanding the extent to which a genotype or the environment cause various phenotypes under homogenous environmental conditions. Since *P. australis* is of high socioeconomic value, knowing the phenotypic characteristics of the specific groups is crucial for choosing appropriate means of cultivation, conservation or utilization of the species.

METHODS

A large collection of *P. australis* representing different phylogeographic groups from all over the world is cultivated in a common garden at Aarhus University, Denmark. From this collection, 77 genotypes of *P. australis* from nine phylogeographic groups with different origins (European, Mediterranean, Far East Australian, South African, Tropical African and four North American groups: introduced, Native, Land and Delta) were selected and replanted in a greenhouse with favorable and homogeneous environmental conditions. The phylogeographic groups are not only genetically different, but differ also in morphological, phenological and ecophysiological characteristics.

The initial fresh and dry weight and biomass allocation of all genotypes were established at the beginning of the experiment to calculate relative growth rate, RGR. Shoot number and height of each shoot were measured at Day 0, Day 30, Day 60, Day 90 and Day 185 to calculate shoot elongation rate, SER. At harvest, the aboveground plant parts were separated into leaves and stems. The belowground biomass was carefully washed to measure maximum rhizome diameter and total rhizome length. All harvested material (leaves, stems, rhizomes+ roots) were fresh weighed respectively and dried in ovens (80 °C) for at least 48 hours to determine the dry weight. Climatic data

of the original growth location for each genotype was retrieved from the WorldClim bioclimatic database.

RESULTS and DISCUSSION

After 185 days grown in a favourable, homogeneous environment, the nine phylogeographic reed groups showed different phenotypic traits: the North American Land group had the highest biomass both for aboveground and belowground parts and thickest rhizome diameter; the European group had the lowest aboveground biomass with the highest shoot number and thinnest rhizome diameter; the Tropical African group had the least belowground biomass with shortest rhizome length; the European, Tropical African and Land group had the highest biomass allocation to leaves, stems and rhizomes+roots, respectively. RGR, rhizome length and rhizome diameter all differed significantly among the groups.

We analysed how the phenotypic differences correlated with the bioclimatic data of the original locations. We found that the European, North American introduced and Native group clustered according to their annual range temperature; the North American Land and Delta group clustered according to precipitation of the wettest month and the coldest quarter of the year; the Mediterranean, Far East Asian and South African group clustered together according to precipitation seasonality and the mean diurnal temperature range (mean of monthly (max temp - min temp)). Our study showed that phenotypic variations of *P. australis* are genetically determined and highly related to the bioclimatic traits of their original locations.

CONCLUSIONS

Most phenotypic traits among the nine phylogeographic groups of *P. australis* were significantly different in the homogeneous environment which suggests that these differences are genetically determined. The climate of their original locations played an important role in developing these differences.

Knowing the properties of the different reed groups allows for selection of suitable reeds for cultivation (e.g. for bioenergy or construction) under proper climatic conditions. Moreover, these results will help us to understand the mechanism of recent invasions of *P. australis* into new ranges.

ACKNOWLEDGEMENTS

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SWS PST 12 - High nutritional value of fish farmed in Veta la Palma

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INTRODUCTION

The aquaculture farm-wetland complex of Veta la Palma (SW Spain) is an example of a commercially viable enterprise within a Natura 2000 Network site. This farm is located in an extensive private estate on a formerly drained marshland of the Guadalquivir river that later became protected. It is currently part of the Doñana Natural Park and the Doñana Reserve of the Biosphere designated by the UNESCO in 1994. Veta la Palma estate is also a Ramsar Site and an Important Bird Area. From the beginning, this estate has been designed and managed to cope with this twofold function as a natural park and an aquaculture business. The key to this success is an active management that promotes a high primary productivity supporting both the natural bird populations and an aquaculture production of 800-1000 tons per year, of which 75% is European sea bass (*Dicentrarchus labrax*).

This ecosystem-based approach to aquaculture relies on the efficiency with which biomass and energy are transferred to higher trophic levels. In aquatic food webs, this efficiency depends more on the quality composition of the primary producers regarding polyunsaturated fatty acids (PUFAs) than on their total biomass (Müller-Navarra et al., 2004). Complex environmental relationships dictates different microalgae blooms in Veta la Palma farm (Fernández-Rodríguez et al., 2015) and some of them are particularly rich in PUFAs (Armada et al., 2013). Our hypothesis is that this natural supply of PUFAs to the base of the food web could explain the higher nutritional value of *D. labrax* grown in Veta la Palma compared to intensively-cultured fish reported elsewhere. We have used the quality composition of PUFAs in wild and farmed fish to make this comparison.

METHODS

In Veta la Palma farm, *D. labrax* is cultured semi-intensively in grow-out fish ponds during up to three years with a combination of natural food and aquafeed supplement. The fish ponds are stocked with fingerlings of *D. labrax* (4-5 fish m⁻³) that have been grown in the farm nursery facilities to about 150 g from fish larvae obtained from an external supplier. The natural food is provided by extensive earthen ponds partially irrigated with tidal water from the Guadalquivir estuary. In November 2009, three sea bass of different weight were harvested and their total lipid extracted following Bligh and Dyer (1959). Fatty acids were determined in triplicate by gas chromatography following Christie (1982). All standard deviations were $\leq 1.3\%$ of the mean value; all

biochemical analyses were performed at the Instituto de Investigaciones Marinas (IIM-CSIC).

RESULTS and DISCUSSION

The total lipid increased as the fish grew due to an increase in triglyceride (fat reserves) while structural lipids (phospholipids) remained relatively constant at 0.75 g per 100 g of muscle. Consequently, the percentages of long-chain PUFAs ($\geq C20$) decreased in large fish from Veta la Palma farm though they were still higher than in intensively-cultured fish from marine cages. Additionally, the concentration of total ω -3 PUFAs and the ratio ω -3: ω -6 were higher in *D. labrax* from Veta la Palma than in wild fish of similar weight (Table 1). Except for linoleic acid (derived from vegetable oils in the aquafeed), Veta la Palma farmed fish quality composition likely benefited from a natural food web based on haptophytes with 15-17% of long-chain PUFAs (Armada et al., 2013).

Table 1. Mean percentage of main PUFAs (in g per 100 g of total fatty acids) in *D. labrax* farmed in Veta la Palma (according to three fish weights) compared to wild populations and sea bass cultured in marine cages (Fuentes et al., 2010).

%	Veta la Palma			Fuentes et al. (2010)		
	Small (450g)	Medium (900g)	Large (1400g)	Wild (440g)	Marine (400g)	cages
18:2 ω -6 (linoleic)	6.34	8.76	9.61	2.73	13.56	9.91
20:4 ω -6	2.34	1.78	1.27	5.37	0.33	0.48
20:5 ω -3 (EPA)	13.50	11.54	9.83	12.17	7.81	9.26
22:6 ω -3 (DHA)	23.83	17.00	13.73	16.62	8.33	7.36
Total ω -3 PUFAs	41.4	33.3	28.5	29.92	17.29	17.81
Total ω -6 PUFAs	8.7	10.5	10.9	9.16	15.87	12.49
Ratio ω -3: ω -6	4.8	3.2	2.6	3.27	1.09	1.43

CONCLUSIONS

Sea bass farmed in Veta la Palma showed a high nutritional value regarding ω -3 PUFAs, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

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