Restoration of the water cycle and natural waterways of Pannonic sodic wetlands in Hungary

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Abstract

The Böddi-szék sodic wetland and its catchment area is one of the most important alkaline habitats in the Carpathian Basin located in the central part of Hungary. Its environment has been changed to a significant extent due to anthropogenic effects which lead to disturbance in the special nutrient cycle of the sodic lake. A LIFE-Nature project was granted in year 2013 with the aim to restore the original water dynamics, the special nutrient cycle and natural habitats. An important element of the project is the translocation of the bisecting canal to help the natural water cycles be operational again. The sustainable model of grazing is to be set up and be operational. To document changes in the land use and changes in the ecological condition a special GIS database system is set up. This complex database is the background of the management planning which should be capable of continuous and dynamic adjustment to accommodate uncertainty, take advantage of new, monitoring based knowledge, and cope with rapid shifts in climatic, ecological, and socio-economic conditions.

Keywords: restoration, sodic lake ecosystem, adjustable management, GIS based monitoring,

Introduction

Pannonian salt steppes and salt marshes occur only in a few countries of the European Union, mainly in the Pannonian bio-geographical region. The largest surface area and the centre of distribution of this habitat type is in Hungary, 99% of the Natura 2000 habitat type 1530 occurs in Hungary. Salt steppes and their associated salt-tolerant herbaceous communities are the western representatives of the continental alkaline vegetation in the Pontic region [15].

Sodic lakes with open water surface differ significantly from the real lakes because of their special nutrient cycle [6]. This phenomenon is of utmost importance for the conservation of their characteristic and valuable flora and fauna.

Böddi-szék is a sodic lake with open water surface and is one of the most important of such wetland habitats in the Carpathian Basin located in the central part of Hungary. The extent of its area is significant with 18% of the open water surface sodic lake subtype of 1530 habitat type in Hungary [8].

A LIFE-Nature project was granted in year 2013 (LIFE12 NAT/HU/001188) with the aim to restore the original water dynamics and natural habitats. Wetlands of the Pannonian biogeographic region of Europe are sensitive ecosystems to climate change effects, observed evidence exists and showing impact like increased average annual temperature and increased drought [3]. Warmer temperature may increase the risk of algal blooms and eutrophication, while inland waters are likely to have lower volume and increased salinisation [18 and 1]. Since healthy resilient ecosystems have a greater potential to mitigate and adapt to climate change [9], in case the water regime of the sodic wetland is damaged, the effects of the climate change may be intensified.

Hydrological background of the sodic lake resilient and vulnerable ecosystem

In the chemical composition of the water of sodic lakes the sodium-hydrogen-carbonate dominates, which causes alkaline pH of the water. Due to their special hydrochemistry, the sodic water form distinctive group inside the continental salt water types. According to the chemical composition of the water of the Böddi-szék sodic lake, it belongs to the less frequent saline-sodic type with great amount of chloride as anion type, its salinity varies in the sub- and hyposaline range (1,7 -14g/l), on the average around 6 g/l (hyposaline) [7 and 16].

The natural water level of sodic lakes fluctuates highly. The dissolved salt content of the groundwater accumulates from vast areas, and moves continuously towards low lying alkaline lakebeds. During wet springs, groundwater pressure is high. During dry, arid summers the water table may sink considerably, superficial lowland water bodies shrink, and the water remaining is gradually withdrawn in the depressions of the lakebed. The salts reach high concentrations within this reduced water volume. The intense evaporation also draws up salty groundwater from deeper strata. During the driest season, lakebeds completely dry out and the salt crystallises out on the surface.

The colour of the sodic water could vary from greyish-white to oil-black. Because of the alkaline pH of the water, the soluble organic matter content is high, thus causes deep brown or black colour [17]. Shallow water of sodic wetlands have greyish-white colour due to the floating particles of the deposit [17]. In this obscured water the light extinction is low, thus hinder the settlement of the photosynthetic algae in large quantities. In the brown and black coloured water the light extinction is higher, which creates more favourable circumstances for photosynthesis thus improves primary production of organic matter. The accumulated organic matter on the lakebed and the shoreline contributes to the creation of dense saltmarsh vegetation.

Sodic lakes are extremely sensitive for the anthropogenic threatening factors, like eutrophication and the decrease of the ground water due to water management. For this reason this sodic lakes with open water surface are endangered habitats in the Pannonian biogeographical region [5]. Based on this, the conservation or the restoration of this open surface ecological succession state of the 1530 Natura 2000 habitat type is of utmost importance.

Anthropogenic effects

The sodic lake and its catchment area changed to a significant extent due to anthropogenic effects which lead to disturbance in the special nutrient cycle of the sodic lake.

The following anthropogenic factors can be considered responsible for the eutrophication and the imbalance of the natural water ways:

1. Draining, eutrophication, hindering of natural turbulence and habitat fragmentation due to the canal crossing the sodic lakebed

Chanel V. was constructed merely for economic reasons and was cut across the sodic lakebed to minimise costs (Figure 1, 2.). The canal has double function, both of them are threatening the sodic lake ecosystem.

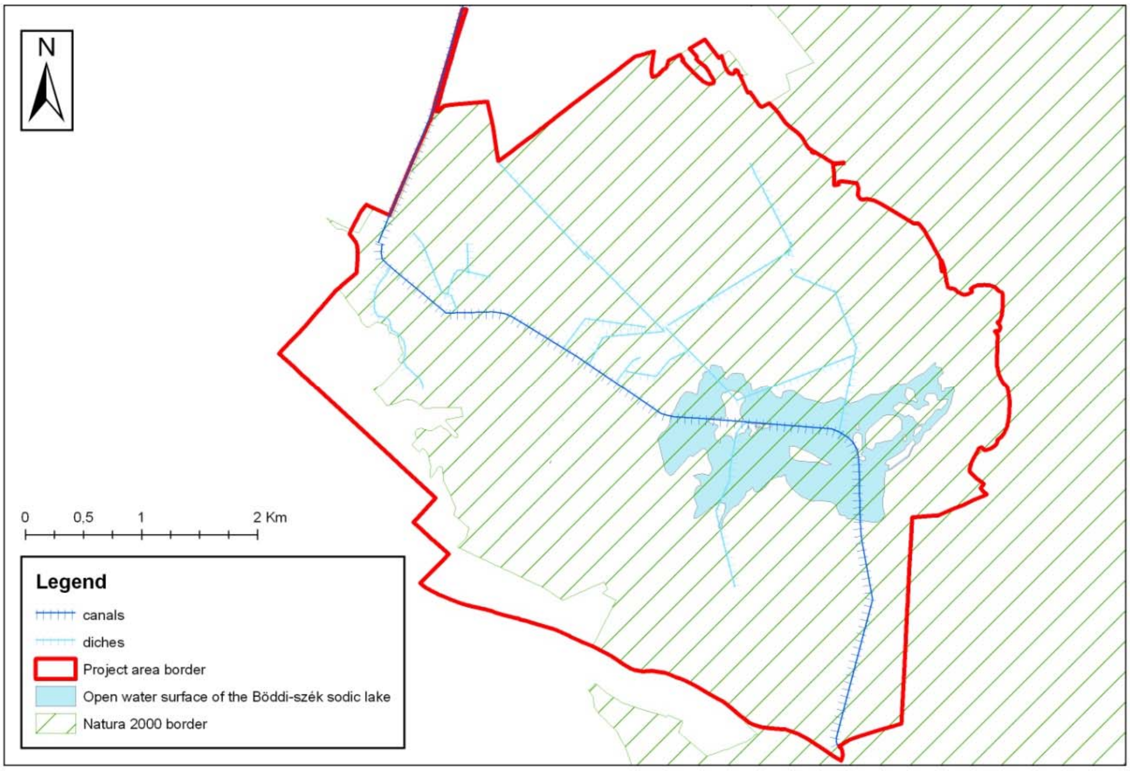

Figure 1. The canal system was created for economic reasons and changed completely the natural water regime of the sodic wetland

1.1. In early spring the canal's main role is to drain inland inundation. Unfortunately, its draining effect is also recognisable in the lakebed as well, which are completely bisected by the channel. Due to this draining effect the lake dries out much sooner than it would in natural conditions, which have negative effects most directly to the characteristic nesting bird communities of alkaline habitats.

1.2. In the driest months (July, August), when sodic lakes are normally drying out, the function of the canal is to bring water from the Danube River for inundation purposes. Due to the high water level in the canal, water is straining through the dam and flowing away in remnants of former side branches of the canal into the lakebed. Since Danube water quality differs significantly from the chemical composition of the sodic water, it causes significant dilution and organic matter enrichment in the sodic water and consequently eutrophication and spreading of the marsh vegetation at the expense of the most valuable sub-types of the 1530 habitats, characteristic for the sodic lakebed is observable.

One of the most important characteristics of the sodic lake with shallow and white coloured water is that the deposit is continuously stirred up by the wind. The turbid water has its greyish-white colour from the floating particles of deposit [17]. In case the turbulence is hindered and particles deposit, the changed light circumstances inside the water causes ecological imbalance and may cause e.g. algal blooms. The traversing canal hinders the resuspension of the deposit by turbulence in the deepest parts of the lakebed, thus lead to ecological imbalance and initiates eutrophication and organic matter accumulation. This leads to a serious degradation of habitat 1530. The dam of Chanel V. traversing the sodic lake encroaches significantly in the ecological system of the formerly integrated lakebed. It is known that the endangering of nature values is often due to habitat fragmentation. The edge of the areas divided into two parts grows significantly, while the surface of the inner 'untouched', intact areas definitely diminishes [14]. Therefore the canal cause serious habitat fragmentation, while negative results of edge effect could also be observed due to spreading of the marsh vegetation at the expense of the most valuable sub-types of the 1530 habitats characteristic for the sodic lakebed.

Figure 2. The canal V. intersects the lakebed thus hinders the natural turbulence and cause habitat fragmentation

2. Lack of appropriate grazing

Due to the organic matter accumulation the extension and density of marsh and reed vegetation has grown rapidly. The dense cover prevents the natural fast drying up and the survival of the specialist flora and fauna. In addition, this dense and tall marsh and reed vegetation with high biomass production do not offer ideal circumstances for grazing, even cattle avoid it. In the absence of grazing or in case grazing does not reach an ecologically sustainable high level the degradation of habitat 1530 is observable.

Due to the unpredictable market trends, change of lifestyle, a shift in preferences and the change of land ownership the once so widespread animal husbandry practices required to maintain sodic wetlands and grasslands habitats have undergone an unfavourable change in the Danube-Tisza interfluve area. Numbers of grazing animals dropped resulting huge undermanaged areas, mostly wetlands, which were not worth to be grazed from the economical point of view. Due to the variable habitat structure of alkaline vegetation, where community types follow each other in zonal or in mosaic-like system [4, 2 and 12] the grazing only with a given type of livestock is not sufficient for the appropriate management of all vegetation types. Wet habitats may cause veterinary problems for sheep, while thin grasslands do not offer enough nutriment for cattle grazing. The lack of grazing livestock or mismanaged grazing will cause serious degradation of habitat 1530 [10, 15]. Therefore, variable types of grazing animals would be necessary to be kept and managed in the area. Ecologically sustainable high level grazing, coupled with trampling could multiply the extent of evaporating surfaces [13] which is a process indispensable for supporting the natural life cycle of the sodic lake ecosystem.

Figure 3. The lack of appropriate grazing has also driven to the spreading of the marsh vegetation, most importantly dominated by reed (*Phragmites australis* (Cav.) Steud.) and bulrush (*Bolboschoenus maritimus* (L.) Palla)

3. Degradation of the cathment area of the sodic lake due to arable farming and non-indigenious, invasive plant species

Inside the project area the extension of 'islands of arable lands' is estimated at around 93 hectares. They are situated in the catchment area of the sodic wetlands and were created mainly by ploughing former 6250 priority habitats. They are still surrounded by natural grasslands (Figure 4.). They cause fragmentation of natural habitat types, and hinder the complex high level grazing management of the catchment area.

Figure 4. Degradation of the catchment area by arable farming

Figure 5. Degradation of the catchment area by spreading of invasive *Elaeagnus angustifolia*

Most of them are still intensively cultivated using fertilizers and pesticides, which contaminate the soil and also the surrounding sodic wetlands hence this agricultural practice threatens the survival of natural plant associations of 1530 habitats and causes eutrophication.
The extended stands of non-indigenous and invasive species occupy mainly valuable priority steppe habitat (6250), and they are continuously spreading. On the project site *Elaeagnus angustifolia* (L.) (Figure 5.), *Robinia pseudoacacia* L. and the herbaceous plant *Asclepias syriaca* L. occurs. Closed stands of invasive species completely destroy the occupied habitat. The man-made linear infrastructures, like the canal and its dyke system offer opportunity for invasive species for spreading. Non-indigenous trees (e.g. E. angustifolia) grown up in the close vicinity of the lakebed mean a crucial risk, because they offer favoured nesting niche for the most common steppe predators (Corvus cornix, Pica pica), which threaten characteristic nesting bird communities of alkaline habitats.

Attempts to improve ecological conditions of the sodic wetland ecosystem

1. An important element of the LIFE-Nature project is the translocation of the bisecting canal. The translocation of 5,9 km section of canal V. crossing the lakebed of the Pannonic sodic lake definitely promotes the natural water cycles be operational again. The former unused canal section with its drainage ditches will be eliminated and filled in to the surface level of the surroundings, in order to rehabilitate sodic lakebed. By the translocation important threatening factors could be eliminated, such as habitat fragmentation, the draining effect in spring, the diluting and eutrophicating effect in the summer months. The natural turbulence will be operational again on the whole surface which helps the resuspension of the deposit in the deepest part of the lakebed. As a result, the open water surface of the sodic lake will increase. The large open water surface helps in retaining and evaporating precipitation which will reduce drought on the micro climatic level. We expect that the cover of the most valuable 1530 micro-habitats (e.g. annual salt pioneer swards of steppes and lakes; dense and tall Puccinellia swards) will increase significantly.

2. In order to hinder the spreading of marsh and reed vegetation, to extend open surfaces thus facilitating the natural water-cycle (sudden spring floods in the lakebed and depressions followed by a rapid evaporation period in summer) of the sodic lake, a sustainable model of grazing will be set up and will be maintained. Conservational concepts regarding management of alkaline vegetation and sodic lakes of Pannonic region (e.g. Natura 2000 plan of the SPA, other LIFE project's (LIFE 2002/NAT/H 8638, LIFE NAT07/H/324) results and management practices [10, 15] underline that the appropriate grazing system is essential in the management of the Pannonic 1530 priority habitats. High level grazing largely contributes to the rolling back of undermanaged marsh and reed vegetations which result a significant increase in the extension of the open water surface of the sodic lake. Grazing will be contributed to the increase of the biodiversity due to the varied microhabitats created by this traditional management type, converting simultaneously the previously neglected biomass to bioproduct. Due to the variable habitat structure of alkaline vegetation, where community types follow each other in zonal or in a mosaic-like system the grazing with one type of livestock is not adequate for the appropriate management of all vegetation types. Therefore the number of the grazing animals and the types of the livestock should be selected according to this phenomenon. From the ecological point of view the most adequate option is to graze native livestock, cattle in the depressions, and sheep, horses and donkeys on the higher reliefs which are best adapted to the ecosystem.

3. In order to reduce the negative effects of the intensive agriculture (like fragmentation of the catchment area, use of fertilizers, pesticides) on the sodic lake, the conversion of ploughlands surrounding the natural habitats is essential. On the newly created grasslands the use of fertilisers will be avoided, which contributes to the habitat improvement measures to upgrade the conservational status of the mis-managed habitats. Reducing human disturbance caused by intensive agriculture in the most sensitive breeding season is essential for the successful breeding and hence for the population growth of species for designation. The increased extension of the semi-natural habitats and the improved habitat structure allows the introduction of high level grazing regimes for nature conservational purposes. As a result, biodiversity is expected to be restored and enhanced. Non-indigenious and invasive species should also be eliminated since they degrade and fragment priority habitat

type of the catchment area. Restructuring black locust plantation with native tree species will improve the adaptation potential of the forest by the more species-rich undergrowth vegetation, while the heterogeneous canopy structure contributes to hinder fire damage.

4. To harmonise and manage restoration activity a GIS based land use planning is to be set up and maintained. The Sustainable Land Use Plan elaborated by site managers. It regulates land use of the site by implementing conservation measures and most importantly the guidelines for the accomplishment of high level grazing.

Sustainable land use plan is harmonizing the intervention actions for conservation in a comprehensive, annually updated Land use Plan, giving practical guidelines for spatial determination of the interventions' area in the given year, the method of interventions and their timing. The Land Use Plan is updated year by year adequately. Updating is an annual feedback, which gives the possibility to take the actual weather and other field factors and the data gained from monitoring of the management effects into account and incorporate them to the plan of the given year. By the regular monitoring activity the effects of the conservational interventions and changes of the ecological state of the sodic wetland habitats managed by special grazing with hydrological (hydrophysical, -chemical) and hydro-biological data could be analysed. Multilayer monitoring analyses are needed to detect the simultaneous changes of the most possible elements of the system. The success of the interventions could only be measured by the positive change of state in the whole system. The monitoring plan was compiled based on the results of the alkaline lake survey of LIFE07NAT/H/000324 program in 2009-2010 which affected the whole Pannonian ecoregion, taking into consideration special circumstances and demands of this project. This way, the results of the habitat development of the project can be compared to and evaluated with the reference survey on the whole region. The year-by-year updated Land Use Plan will definitely helps the efforts to improve water regime and adaptation capacity of the whole sodic wetland ecosystem by the restoration activity.

Conclusions

The negative effects of the human activities and the changes of environmental conditions increase the loss of biodiversity. Conservation actions are going to be implemented to diminish these negative effects and improve habitat conditions.

It is however clear, that the presently insufficient common knowledge on sodic lake ecosystem has to be changed for the long-term survival of this site which is particularly dependent on attitudes of local people. The success of conservation work can be greatly enhanced and secured if there is an adequate level of raising local awareness for support. This support has to have a wide social basis, has to be inclusive of several social and age groups. Besides these people the wider community also needs to be addressed (e.g. tourists). Locals, stakeholders, officers of local authorities are not enough aware of the values of their nearby natural surroundings. One part of the problem is that these people have not been involved for a long time and have been made passive participants. There is also a common view among farmers that natural, uncultivated land represents no value. Most members of the old generation who were still aware of the rich natural heritage of their countryside and the traditional management of these habitats have already passed away, and in many cases the children did not inherit their parents attitude towards nature. This process has led to general negligence, indifference and negative attitudes. The old generation knew exactly the natural processes of the area managed by them however their knowledge was experimental rather than scientific.

To halt the further loss of biodiversity was one of the main reason for the national level protection of Böddi-szék as an 'ex lege sodic lake' obtained as late as in 1997. The EU's Natura 2000 conservation network is crucial in providing the ambience for natural species need to adapt to environmental change. The importance of the range of ecosystem services provided by Natura 2000 and other protected areas is often underestimated, but they meet a variety of human needs [11]. To effectively improve impacts of the conservational efforts the exact specification, monitoring and analysing of ecosystem services is also essential.

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References

[1] Alcamo, J., J.M. Moreno, B. Nováky, M. Bindi, R. Corobov, R.J.N. Devoy, C. Giannakopoulos, E. Martin, J.E. Olesen, A. Shvidenko, 2007: Europe. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 541-580.

[2] Bagi, I., Zs. Molnár, F5 – Padkás szikesek, szikes tavak iszap- és vakszik növényzete. In: J. Bölöni, Zs. Molnár, A. Kun. (Ed.) (2011): Magyarország élőhelyei-vegetációtípusok leírása és határozója. MTA Ökológiai és Botanikai Kutatóintézete, Vácrátót, (2011) pp 135-139.

[3] Bertzky, M., B. Dickson, R. Galt, E. Glen, M. Harley, N. Hodgson, G. Keder, I. Lysenko, M. Pooley, C. Ravilious, T. Sajwaj, R. Schiopu, Y. de Soye & G. Tucker, Impacts of climate change and selected renewable energy infrastructures on EU biodiversity and the Natura 2000 network: Summary Report. European Commission and International Union for Conservation of Nature, Brussels. (2010) pp. 28.

[4] Borhidi, A., Magyarország növénytársulásai, Akadémiai Kiadó, Budapest, (2003) 610 pp.

[5] Boros, E., Alkaline lakes. National Ecological Network 4. Edited by the Authority for Nature Conservation, Ministry of Environment and Water, Based on the Hungarian edition, (2003) pp 30.

[6] Boros, E., Vízimadarak és fontosabb háttérváltozók szerepe fehér szikes vizek trofikus kapcsolataiban. PhD Thesis. University of Debrecen. (2007) pp. 119.

[7] Boros, E., L. Vörös, A magyarországi szikes tavak sótartalma és ionösszetétele, In.: Gy. Dévai, L. Vörös, (Ed.), Tanulmányok a Pannon ökorégió szikes víztereiről I. kötet. Acta biologica Debrecina. Supplementum oecologica hungarica (2010) **22** pp. 37-51, 195.

[8] Boros, E., A. Molnár, P. Olajos, A.A. Takács, G. Jakab, Gy. Dévai, Nyílt vízfelszínű szikes élőhelyek elterjedése, térinformatikai adatbázisa és természetvédelmi helyzete a pannon biogeográfiai régióban. Hidrológiai közlöny (2006): 6, pp. 146-148.

[9] European Community, Nature's role in climate change. Nature and biodiversity. (2009), http://ec.europa.eu/environment/nature/info/pubs/docs/climate_change/en.pdf Accessed 10. February, 2014

[10] Kelemen, J. (Ed.), Irányelvek a füves területek természetvédelmi szempontú kezeléséhez, TermészetBÚVÁR Alapítvány, Budapest, (1997) pp. 388 ·

[11] Landsberg, F., S. Ozment, M. Stickler, N. Henninger, J. Treweek, O. Venn, and G. Mock, Ecosystem Services Review for Impact Assessment: Introduction and Guide to Scoping. WRI Working Paper. World Resources Institute, Washington (2011) DC.
http://www.wri.org/publication/ecosystemservices-review-for-impact-assessment. Accessed 10. February, 2014

[12] Mile, O., Relationship between soil heterogenity and vegetation in saline area, Thesises of Ph.D Dissertation, Debrecen. (2008), pp. 24.

[13] Nagy, G. G., E. Déri, Sz. Lengyel, Irányelvek a pannon száraz lösz- és szikespuszta gyepek rekonstrukciójához és természetvédelmi szempontú kezeléséhez. Hortobágyi Nemzeti Park Igazgatóság, Debrecen, 2008, pp. 57.

[14] Standovár, R.P. , T. Primack, A természetvédelmi biológia alapjai, Nemzeti Tankönyvkiadó, (2001) pp. 271

[15] Stanová, V. Š., M. Janák, J. Ripka, MANAGEMENT of Natura 2000 habitats * Pannonic salt steppes and salt marshes 1530. Technical report. DAPHNE-Institute of Applied Ecology, Slovak Republic (2008) pp. 22.

[16] Váradi, Zs., G. Fehér, Kiskunsági szikes tavak kémiai vizsgálata, In.: Gy. Dévai, L. Vörös, (Ed.), Tanulmányok a Pannon ökorégió szikes víztereiről I. kötet. Acta biologica Debrecina. Supplementum oecologica hungarica (2010) **22** pp. 53-74.

[17] V-Balogh, K., B. Németh, L. Vörös, Szervesanyagok magyarországi fehér vizű szikes tavakban, In.: Gy. Dévai, L. Vörös, (Ed.), Tanulmányok a Pannon ökorégió szikes víztereiről I. kötet. Acta biologica Debrecina. Supplementum oecologica hungarica (2010) **22** pp. 75-86, 196-200.

[18] Williams, W. D., Anthropogenic salinisation of inland waters. Hydrobiologia, (2001) **466**, pp. 329-337.