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PORTRAIT OF THE INTERREG IPA PROJECT BETWEEN CROATIA AND SERBIA, SeNs WETLANDS

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Abstract: The main objective of the SeNs Wetlands Project is to enforce integrated cross-border analytical monitoring of key physicochemical parameters and existing risks, as well as protection of the aquatic and terrestrial environment and biodiversity. The research is performed in cooperation of Faculty of technical sciences, University of Novi Sad, Institute for Nature Conservation of Vojvodina Province, Serbia, Faculty of Electrical Engineering, Computer Science and Information Technology, University of Osijek, and Public Institution for Management of Protected Natural Values of Vukovar-Srijem County, Croatia within the Interreg IPA CBC Croatia-Serbia Project „Active SEnsor monitoring Network and environmental evaluation for protection and wiSe use of WETLANDS and other surface waters“, with acronym SeNs Wetlands, financed by EU realized through 5 work packages in the period of 3 years. The Lake Zobnatica, Serbia and the Wetlands of Tompojevci, Croatia, protected natural areas surrounded by agricultural land, are selected as representative areaels for the research field of the Project SeNs Wetlands. Wetlands are aquatic open or semi-closed water bodies with complex and diverse biota that are highly sensitive and vulnerable aquatic bodies, due to the agricultural exploitation and communal pollution. The results of pollution analysis provide bases for development of guidelines specified for the growth and maintenance of a protective green belt around the Lake and the Wetlands, which are proven to minimize or eliminate pollution. The key physicochemical parameters that were followed are pH, air and water temperature, electroconductivity, dissolved oxygen, chemical oxygen demand (COD), biological oxygen demand (BOD_5), total organic carbon (TOC), anions - nitrites ($NO^{2-}_{(aq)}$) and nitrates ($NO^{3-}_{(aq)}$), orthophosphates ($PO_4^{3-}_{(aq)}$) and ammonium nitrogen cation (NH_4^+-$N_{(aq)}$), total nitrogen and phosphorus, sulphates ($SO_4^{2-}_{(aq)}$), chlorides ($Cl^-_{(aq)}$), fluorides ($F^-_{(aq)}$), total chlorine and cations of metals (nickel (Ni^{2+}(aq)), iron ($Fe^{2/3+}$(aq)), zinc (Zn^{2+} (aq)), chromium (Cr^{6+}(aq)), copper ($Cu^{2+}_{(aq)}$).
Keywords: SeNs Wetlands, Interreg Project, key physicochemical parameters, sensors, protective green belt

1. INTRODUCTION

The key objective and goals of the SeNs Wetlands Project are to implement integrated cross-border monitoring for key physicochemical parameters and existing risks, as well as the protection of protected aquatic areas and biodiversity [1]. The Project will be carried out by implementation of integrated continuous monitoring system for the purpose of cross-border data collection and evaluation. The expected changes are improvement of the knowledge level and existing data, development of guidelines for surface and groundwater and biodiversity protection, use of modern sensor methods. The results will be the Guidebook, for the establishment and maintaining vegetated green strips along the banks of surface waters in agriculture landscapes of Pannonia Region. The optimal structure of multifunctional bank vegetation belt can be defined by the analysis of merged data. The main target groups are Municipalities and Local Authority, Local Community, Public Utilities, Private and Governmental Institutions, Environmental and civil NGOs and University and Research Institutes.

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The Project sites are within hydrological systems of watercourses recognized as ecological corridors. The Wetland of Tompojevci in Croatia and the Lake Zobnatica in Serbia have a direct influence on the water quality of water bodies which are under the umbrella of the geo-network Natura 2000 site. Water pollution from agricultural sources is a common problem of both Serbia and Croatia. The water quality is one of the drivers of biodiversity depletion in wetlands. Buffer/filter function of the bankside vegetation have not been recognized widely, field data from the Pannonia region are scarce and mostly gained by indirect methods. The continuous monitoring by sensors located in measurement wells will produce data about the quantity and seasonal dynamics of the most important pollutants responsible for the eutrophication. Direct beneficiaries of the Project will be the local municipalities and/or water authorities, and the general public. Indirect benefits will be accessible data for all stakeholders. The Project SeNs Wetlands emerged from the necessity of applying an extra effort in the process of protection of wetlands and habitats which represent the most sensitive and endangered ecological systems. Wetlands are areas of diverse biota that are becoming more sensitive and vulnerable by modernization and exploitation, mainly due to exponential growth of agricultural activities.

Impaired and degraded ecosystems have reduced tolerance and adaptability to variation of environmental condition and climate change. The optimal revitalization of ecosystem require high inter and transdisciplinary, cross-border activities. The Project addresses one of the major cross-border challenges of the Pannonia Region and the bordering agricultural landscapes characterized by the high percentage of arable land and increased pressures on the natural systems. Water pollution from agricultural sources is a common cross-border problem, caused by cultivation reaching the edge of water. Although the natural habitats are heavily fragmented, a significant number of existing and planned Natura 2000 sites are in the region. Project sites are within hydrological systems of watercourses (Bosut in Croatia, Krivaja in Serbia) recognized as ecological corridors. The wetland in Croatia have a direct effect on the water quality of the Natura 2000 site located downstream, and the project site in Serbia is proposed for the protection as Nature Park. The key goals of the SeNs Wetlands Project are monitoring of water quality, nurturing and maintaining flora (green belt) and fauna, education on purpose of vegetation in the wetland ecosystem and positive effects on the sustainable development of the area. The dissemination of the Project results will provide data to research facilities, water authorities, local community and the general public. The pollution analysis will provide bases for development of guidelines and the Guidebook specified for the growth and maintenance of a protective green belt that is proven to minimize or eliminate contaminants.

Laboratory analysis of collected and in-situ measurement of physicochemical parameters of groundwater wells, run-off and surface water samples from 18 locations in Serbia, and 14 in Croatia. Data obtained in laboratory conditions and *in-situ* by developed FOS are evaluated and discussed in order to obtain the realistic presentation of the ecological network pollution and possibility to recommend innovated policies to reduce water pollution. In this part of the Project life only the results for the measured physicochemical parameters are shown according to the work package Implementation.

All the key physicochemical parameters (in Serbia and Croatia) will be the result of collaboration of the Project Partners. The analytical determination of key physicochemical parameters is performed in Accredited Laboratory for environmental and occupational monitoring, Department of Environmental Engineering and Occupational Safety, Faculty of Technical sciences, University of Novi Sad. These types of research have been performed for the first time in Serbia and Croatia within the Interreg IPA CBC Croatia-Serbia Project „Active SEnsor monitoring Network and environmental evaluation for protection and wiSe use of WETLANDS and other surface waters“ AF_HR-RS135_SeNs_Wetlands financed by European Union.

2. MATERIALS, METHODSAND SAMPLING SITES

The level values of physicochemical parameters and different type of sources of wastewater (industrial, agricultural and domestic) are poorly researched and still highly unknown, particularly in Western Balkan countries. Sensitive water bodies, the Lake Zobnatica and the Wetlands of Tompojevci, are surrounded by agricultural land, and Lake Zobnatica, as a countryside touristic destination, has a vast number of implemented leisure activities (Figure 1).

The seasonal sampling for quantitative and qualitative analysis of the selected physicochemical parameters of water by standard analytical laboratory techniques and fiber optic sensors (FOS) were conducted. The key physicochemical parameters pH, electroconductivity, dissolved oxygen,

COD, BOD_5, TOC, anions – $NO_2^-(aq)$ and $NO_3^-(aq)$, $PO_4^{3-}(aq)$ and NH_4^+-N (aq), total nitrogen and phosphorus, $SO_4^{2-}(aq)$, $Cl^-(aq)$, $F^-(aq)$, Cl_2, and cations of metals ($Ni^{2+}(aq)$, $Fe^{2/3+}(aq)$, Zn^{2+} (aq), $Cr^{6+}(aq)$, $Cu^{2+}(aq)$) are performed in Accredited Laboratory. Laboratory analyses of physicochemical parameters of run-off, groundwater and surface water samples from 18 locations in Serbia, and 14 in Croatia are performed. Key physicochemical parameters were selected for determination by FOS device. Laboratory equipment based on FOS will be developed and calibrated to monitor the quality of the studied water bodies. Analysed physicochemical parameters in water by FOS device are: NO_2^- and NO_3^-, NH_4-N, Cl_2, PO_4^-, SO_4^{2-}, $Cl^-(aq)$, $F^-(aq)$, Ni^{2+}, Fe^{3+}, Zn^{2+}, Cr^{6+}, Cu^{2+}.

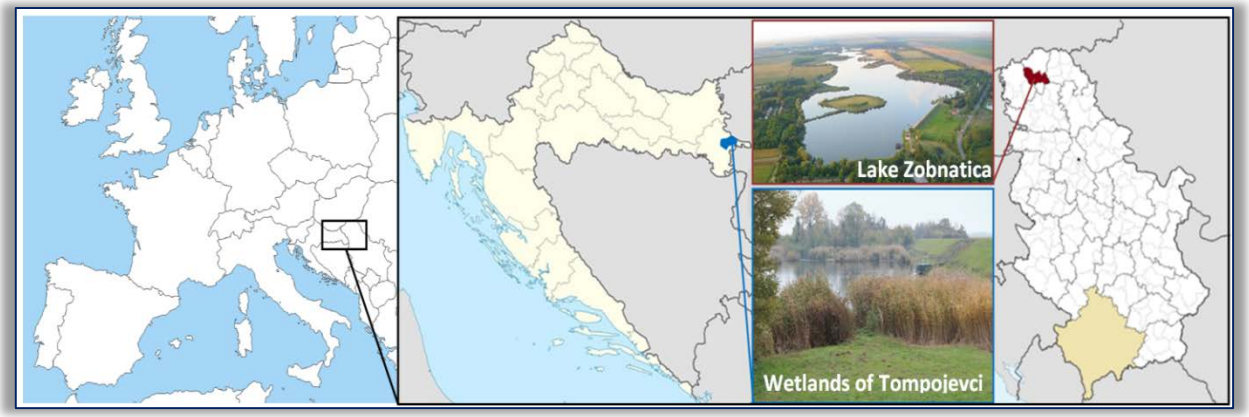

Figure 1. The wetlands of Tompojevci and the Lake of Zobnatica – Project experimental sites

Preliminary screening and sampling of Lake Zobnatica surface water, in the vicinity of Bačka Topola, Vojvodina, Serbia, were conducted on 17th November of 2017, and 28th May of 2018. Sampling campaigns of ground water, surface water and run-off water in the vicinity of Lake Zobnatica were conducted on 2ndJuly 2018 and 30thAugust 2018, after the piezometers (labelled B1 to B9) and collectors were positioned, constructed and installed. During the sampling campaigns there was no precipitation and the air temperatures were 28°C and 35°C, respectively. Ground water was collected from piezometers B1 to B9. Sampling sites B1, B8 and B9 are located in agricultural area, B2, and B3 are near the Lake. Forest and grass are between B1, B2 and B3 sampling sites, and B4 – B7 are in green belt area.

Preliminary screening and sampling of surface water in protected area of Wetlands of Tompojevci, Croatia, were conducted on 24thJanuary of 2018, and 24thApril of 2018. Sampling campaign of ground water and surface water in Wetlands of Tompojevci was conducted on 7th September of 2018, after the piezometers (labelled P1 to P6) were positioned, constructed and installed. During the sampling campaign there was no precipitation and the air temperature was 28°C. Sampling procedure is shown in Figure 2.

Figure 2. Sampling campaigns on representative locations of Lake Zobnatica and wetland Tompojevci

The classification of surface water quality prescribed by Regulation on emission limit values of polluting substances in surface and groundwater and deadlines for their achievement (Official Gazette of the RS 50/2012) is shown in Table 1 and Table 2.

Table 1. The limit values of physicochemical parameters for classification of water quality, Regulation on emission limit values of polluting substances in surface and groundwater and deadlines for their achievement (Official Gazette of the RS 50/2012).

Parameter	Class I	Class II	Class III	Class IV	Class V
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	<6.5 or >8.5
EC	<1000/BLQ	1000	1500	3000	>3000
DO	- / BLQ	- / BLQ	5	4	<4
PO_4^{3-}	- / BLQ	-	0.2	0.5	>0.5
NO_2^-	0.01 / BLQ	0.03	0.12	0.3	0.3
NO_3^-	- / BLQ	-	6	15	>15
NH_4^+-N	- / BLQ	-	0.6	1.5	>1.5
$SO_4^{2-}{}_{(aq)}$	50 / BLQ	100	200	300	>300
$Cl^-{}_{(aq)}$	50 / BLQ	-	150	250	>250
Cl_{tot}	0.005	0.005	-	-	-
TOC	- / BLQ	-	15	50	>50
COD	10 / BLQ	15	30	125	>125
BOD_5	- / BLQ	-	7	25	>25
Cr_{tot}	25 / BLQ	50	100	250	>250
$Cu^{2+}{}_{(aq)}$	5/22/40/112	5/22/40/112	500	1000	>1000
$Zn^{2+}{}_{(aq)}$	30/200/300/500	300/700/1000/2000	2000	5000	>5000
$Fe^{2/3+}{}_{(aq)}$	200	500	1000	2000	>2000
Phenols	<1	1	20	50	>50

Table 2. The maximum allowable values of physicochemical parameters for class I and II quality of water for lakes below 200 m of sea level (Official Gazette of the RS 50/2012)

Parameter of surface water	Maximum allowable values for class I	Maximum allowable values for class II
pH	6.5-8.5	6.5-8.5
DO	8.52	7
TOC	2	6
BOD_5	2	5
NH_4^+-N	0.1	0.3
NO_3^-	1	3
PO_4^{3-}	0.02	0.1
P_{tot}	0.05	0.2
Cl^-	50	100

3. RESULTS AND DISCUSSION

SeNs Wetlands Project apostrophizes the major cross-border challenge of the Pannonia Region and the bordering agricultural land characterized by the increased pressures on the natural systems. Water pollution from agricultural sources is a common cross-border problem. The poor water quality is the cause of the minimization of biodiversity and often makes surface waters inadequate for irrigation. Surface and ground water pollution from agricultural sources is a persistent and demanding cross-border problem.

The selected results of key physicochemical parameters for 2018 and 2019 are shown as maximum and minimum measured concentration levels (Table 3).

The planned biodiversity survey enables the comparison of the buffer capacity and habitat quality of the bank vegetation.

According to the results and maximal allowable values Wetlands of Tompojevci belongs to the class V water quality (orthophosphates and dissolved oxygen), with high trophic state and bad eco-status. The results of preliminary screening analyses in Wetlands of Tompojevci indicated pollution and need for detailed monitoring of surface water as well as ground water and run-off water. The preliminary results and maximal allowable values show that water of the Lake Zobnatica can be classified as class IV at best, as poor ecological status and utilization for irrigation and industrial use (process and cooling water) [2, 3].

Following the development and progress of the Project the parameters that show the most substantial for the analytical study of the wetlands in Tompojevci and Lake Zobnatica are pH, dissolved oxygen, conductivity, orthophosphates, nitrates, nitrites and total nitrogen. The sensors of FOS system are in the process of development expected to be set on locations, but the preliminary results are abundant and enable the development of insights and conclusions.

Table 3. Results of physicochemical parameters in the vicinity of the Lake Zobnatica and Wetlands of Tompojevci

The Lake Zobnatica						
Parameter	SWmin	SWmax	ROmin	ROmax	GWmin	GWmax
pH	7.08	9.66	7.08	9.43	6.95	9.09
EC	926	1165	134	678	477	1446
DO	5.14	11.05	0.80	10.35	0.80	7.53
NO_3^-	0.001	0.188	<0.002	0.92	0.001	0.80
NO_2^-	0.008	0.01	<0.01	3.50	0.008	3.42
NH_4^+-N	0.01	0.14	<0.01	3	<0.01	2.5
TN	<1	2.54	<1	73.26	<1	76.23
$PO_4^{3-}{}_{(aq)}$	<0.01	1.263	0.089	4.494	<0.01	8.042
Cl_{tot}	0.01	0.14	<0.01	1.66	0.01	0.16
$Cl^-{}_{(aq)}$	3.4	82.9	1.7	47.7	<0.01	144.1
$F^-{}_{(aq)}$	0.13	2.29	<0.02	0.51	0.03	2.56
Cr^{6+}	<0.01	0.015	<0.001	0.675	<0.01	0.039
$SO_4^{2-}{}_{(aq)}$	43	98	1	99	0	94
$Ni^{2+}{}_{(aq)}$	<0.006	0.003	<0.006	0.18	<0.006	0.021
$Fe^{2/3+}{}_{(aq)}$	<0.02	0.50	<0.02	3.78	<0.02	0.38
$Zn^{2+}{}_{(aq)}$	0.07	0.28	<0.01	1.4	0.06	0.54
$Cu^{2+}{}_{(aq)}$	<1	10	<1	82	2	35
TOC	11.14	22.54	6.906	42.85	3.385	46.441
COD	21.2	52.3	12.2	78.6	1.01	346
BOD_5	1.21	7.31	0.36	3	0.3	3.26
Wetalands Tompojevci						
Parameter	SWmin	SWmax	ROmin	ROmax	GWmin	GWmax
pH	7.19	8.07	7.02	7.73	6.96	12.80
EC	308	948	173	502	298	1218
DO	3.77	5.62	0.68	5.86	1.59	9
NO_3^-	0.001	0.008	0.009	0.235	0.003	0.291
NO_2^-	< 0.01	0.03	0.04	1.11	0.01	1.83
NH_4^+-N	0.01	1.29	0.04	3	< 0.01	3.88
TN	<1	4	<1	275.68	<1	46.99
$PO_4^{3-}{}_{(aq)}$	<0.01	9.403	< 0.01	10.875	<0.01	10.886
Cl_{tot}	0.01	0.14	-	-	0.01	0.41
$Cl^-{}_{(aq)}$	6.2	37.2	0.2	80.5	2.3	45
$F^-{}_{(aq)}$	<0.02	0.40	<0.02	2.97	<0.02	1.24
Cr^{6+}	0.003	0.037	<0.01	0.097	0.004	0.636
$SO_4^{2-}{}_{(aq)}$	1	63	1	27	1	98
$Ni^{2+}{}_{(aq)}$	<0.006	0.019	<0.006	0.072	<0.006	0.033
$Fe^{2/3+}{}_{(aq)}$	0.03	1.16	<0.02	0.84	0.01	0.99
$Zn^{2+}{}_{(aq)}$	0.09	0.66	0.27	2.73	0.01	1.04
$Cu^{2+}{}_{(aq)}$	1	12	1	132	1	50
TOC	6.7	20.7	9.8	79.90	2.53	141.48
COD	18.5	56.2	17.8	180	0.137	170
BOD_5	0.12	2.66	-	-	0.1	2.58
Table and sample legend	SW – surface water		RO – run-off		GW – ground water	
	Normal font – values within the limits for class I		Italic font – values over the limits for class II		Boldfont – values over the limits for class V	

All obtained results of sampled ground and surface water, indicate significant pollution, leading to the conclusion that the surrounding agricultural land has high impact onto the sensitive water bodies Wetlands of Tompojevci, Croatia and the Lake Zobnatica, Serbia.

4. CONCLUSIONS

The SeNs Wetlands Project main objective is development of integrated cross-border monitoring for protection of environment and biodiversity, which will provide the first and the new cross-border data correlation and evaluation. Specific objectives of the Project are development and implementation of active sensor monitoring system which will provide cross-border database; analysis of physicochemical parameters in water by standard analytical and new fiber optic sensor methods; definition of guidelines for enhancing the ecosystem services of bankside vegetation in the agricultural landscapes in Pannonia region and adjacent areas; collection of data about the interests of local communities and other stakeholders in the sustainable use of the multifunctional vegetation strips. The SeNs Wetlands Project main outputs are Development of wireless water quality measurement stations and monitoring network system for Data Acquisition, Processing and

Presentation (DAPP); New fiber optic sensor (FOS) for monitoring of environmental water quality; Examination of environmental water quality inside the structural elements of the ecological network and measurement wells; Guidelines for the establishment of multifunctional bankside vegetation strips and plan for the establishment of multifunctional vegetation strip.

Highly inter and multidisciplinary area of environmental protection has a significant segment of transdisciplinarity, cross-border and inter regional character. The significance of the obtained results is also the possibility to disseminate knowledge, experiences to wider areas of similar geological, climatic and physical-chemical characteristics.

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