4th SmallWat21v

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INDICE

APPLICATION OF FLOATING WETLAND ISLANDS FOR WATER AND HABITAT PROMOTION IN TWO CONTEXTS: URBAN RIVER AND SMALL FISH FARM

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Abstract

Despite the proven vital importance of freshwater ecosystems for humanity, those continue to be subjected of accelerated ecological degradation. Floating wetland islands (FWI) - one of bioengineering technologies classified as nature-based solutions – have shown ability to assist the reduction of nutrient concentrations, improving water and habitat quality for wildlife. Therefore, if properly used, FWI can be important tools for assisting the sustainable management and the rehabilitation of these ecosystems. Herein, are presented two proposals for FWI installation: one concerning the water and habitat quality improvement of an urban river section (Case 1); the other aiming the reduction of the small fish farm outflow impact on downstream water quality and the improvement of reared fish welfare (Case 2).

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INTRODUCTION

Societies and ecosystems are highly dependent on water resources. Therefore, a strategic water management is critical to achieve sustainable development, in all its dimensions (UNESCO, UN-Water (2020)). When considering specific water bodies that are subject to certain types of contamination or pressures, like some rivers, lakes, and aquaculture production sites, the water quality assessment and mitigation plan pose a major concern. It is thus important to find sustainable solutions to pollution mitigation and biodiversity promotion. Several contaminants can be biologically degraded, or uptake by plants, through the application of phytoremediation technologies, such as wetland systems (constructed or floating) (Calheiros 2015, 2020). Floating wetlands islands (FWI) are an innovative variant of the traditional constructed wetlands, being a man-made ecosystem intending to mimic the depurative processes that naturally occur in wetlands. Their main applications have been related with the treatment of stormwater, sewage, eutrophic lake water and water supply reservoirs (e.g., Colares et al, 2020; Bi et al, 2019). However, there is a great unexplored potential for FWI application in other situations, such as urban rivers and fish farms.

Urban rivers and streams are crucial to cities, because they provide environmental, cultural and aesthetical services that are essential to maintaining urban environmental quality (Hua & Chen, 2019). Nevertheless, in urban areas there is a range of stressors impacting the integrity of these ecosystems, namely high nutrient levels and contamination resulting from point and diffuse loadings arriving from several sources. Besides, many of the so called "urban river rehabilitation actions", carried out either the past, either recently, promoted the regularization of the riverbeds and the riverbanks leading to riparian wood elimination. The environmental consequences of fish farming can be potentially negative. Reduction in dissolved oxygen, increase in biochemical oxygen demand (BOD) and in nutrient concentrations downstream are the main consequences if fish farms are carried out without effluent treatment (Fidalgo, 2002; Crispim et al 2009). Besides, another issue is fish welfare (Braithwaite and Salvanes, 2010).

The main objective of this study is to present two proposals for FWI installation: one concerning the water and habitat quality improvement of an urban river section -Fervença River- (Case 1); the other aiming the reduction of the fish farm outflow impact on downstream water quality and the improvement of reared fish welfare (Case 2).

METHODS

Case 1: The Fervença River is located into Portuguese part of the Douro basin (latitude: 41°47'N; longitude 6°46'W), is about 25 km long, and it is regarded as an urban river, because flows through the city of Bragança (21 853 inhabitants in 2011). Along its course it encounters nonpoint sources of pollution, originated by agricultural activities, and point sources of pollution from some villages located in the vicinity. Further downstream, in the core urban area, along 630 m riverbed was regulated with five weirs, an artificial concrete riverbank was created and the riparian wood was partially eliminated (Fig 1).

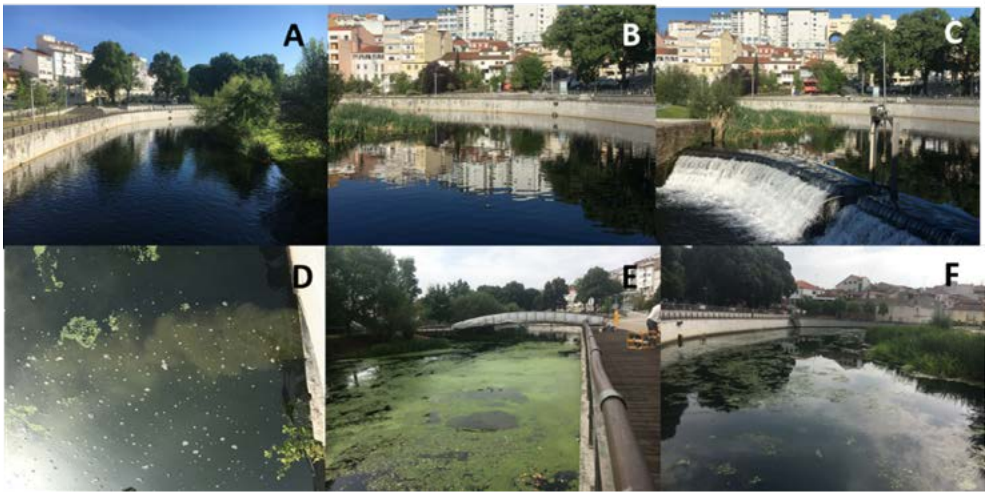

Figure 1. *Fervença river section located in the core urban area (A-C). Point source of pollution (D); algal summer blooms (E,F).*

Case 2: Posto Aquícola de Castrelos, is a small fish farm unit of governmental services: the Portuguese Conservation of Nature and Forest Institute (ICNF). Located in northeastern Portugal (41 50' N; 6° 53'W) in the right bank of Baceiro River, a mountainous oligotrophic river, is mainly used to rear brown trout (*Salmo trutta*) and endemic cyprinid for fish stocking and conservation. Fish are grown in outdoors concrete tanks, in a flow through system, and the effluents are discharged untreated directly into River Baceiro (Douro basin) (Fig 2).

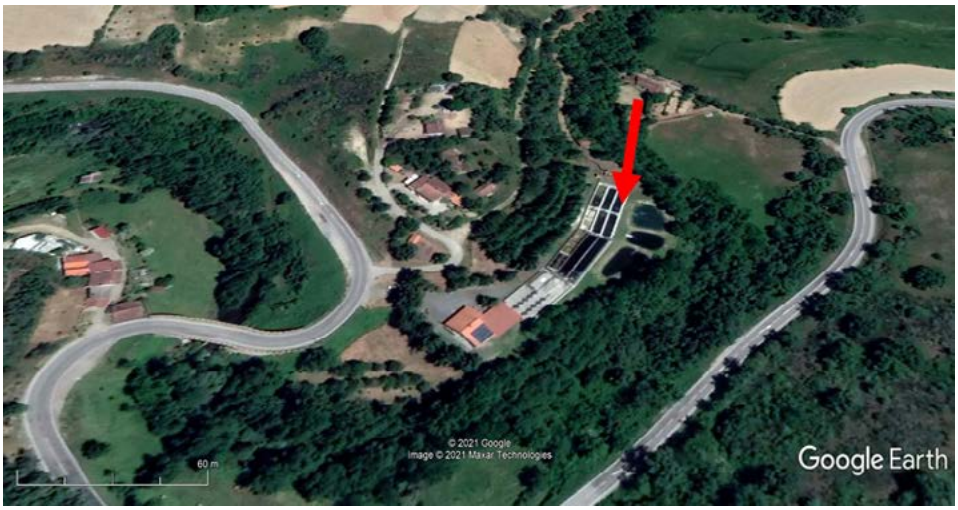

Figure 2. *Posto Aquícola de Castrelos facility (the red arrow points the outdoor tanks)*

For both cases, the following steps were carried out: i) Diagnosis of the current environmental state; ii) Evaluation of which areas could be targeted for the installation of FWI; iii) Presentation of a preliminary proposal for the installation of FWI. The necessary information supporting both proposals was obtained from literature.

RESULTS AND DISCUSSION

Case 1: Large variation range was observed in all studied parameters related to water quality. The concentrations of total phosphorus and phosphates were the highest in the summer when the flow was reduced (Nogueira, 2020). In this area, mainly during the summer, algal blooms, generally occur. The water quality as well as the visual quality of the landscape is negatively impacted when these blooms occur (Fig 1). Nevertheless, this river section still supporting fish species, including endemic species of river Douro basin, as well as water birds and, amphibians. Besides, the otter (*Lutra lutra*) occasionally visits this river section. Therefore, the main goal of the present plan is to recreate environments for habitat, assist pollution and algal blooms reduction in the river and ultimately to promote recreational and educational activities in the area. According to the available literature the FWI installation could allow to reach the mentioned goals. However, the present proposal should consider the following issues:

a) FWI should be placed along the urban section of the river nearby the fully artificialized riverbank in order to increase habitat availability and to prevent the dragging by the high winter river flow;
b) The local ecotypes of macrophytes, whose ability to remove nutrients is well known (e,g., *Juncus effusus*, *Iris pseudocorus*, *Typha* sp. and *Phragmites australis*) should be preferentially used.
c) The extent of coverage area, in a first approach, should be at least 10% of urban riverbed area (e.g., Grosshans et al, 2019). Nevertheless, a future design study taking into account different scenarios of polluting loads and expected removal rates should be carried out in order to adjust the extent of surface coverage.
d) Vegetate the vertical concrete wall using vertical fencing structures, allowing the future installation of local riparian shrubs and trees. This will introduce new hydrological patterns promoting sediment retention and new habitats.
e) Periodical and long-term monitoring should be essentially focused on (1) the integrity of the beds and monitor the development of vegetation .and of the associated biofilm; (2) the effects of FWI on water quality and aquatic ecosystem integrity methods (e.g., nutrient concentrations macroinvertebrate and diatoms indices); (3) monitoring fish, amphibian and bird populations;
f) Involvement of municipality and other stakeholders;
g) Promotion of educational activities in schools and in other public places concerning the importance of freshwater ecosystems for humanity.

The expected environmental and aesthetic outcomes are presented in Fig. 3. Socio-Economic outcomes are also expected (more walkways, bring more life to this area of the town, revitalize small business along the river edge and more educational, cultural and recreational activities along the urban riverine area.

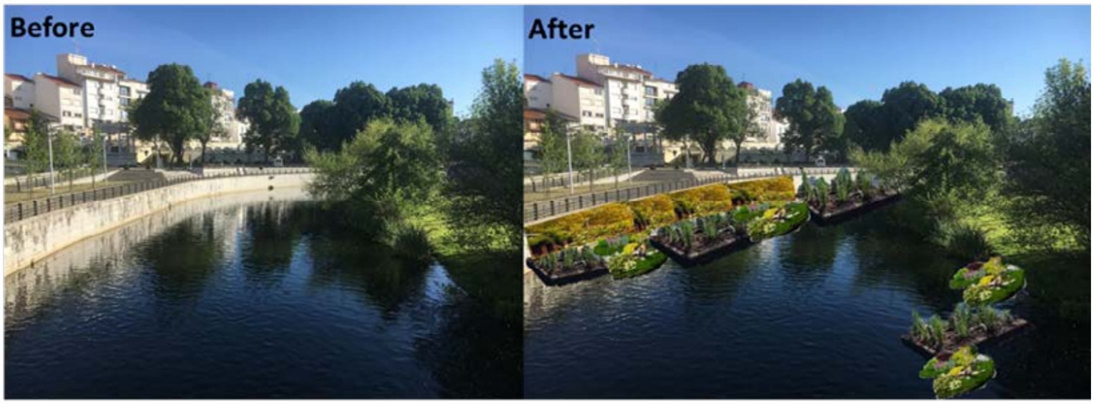

Figure 3. *Simulation the environmental and aesthetic effects of FWI placement.*

Case 2: Increase on BOD, ammonia, total phosphorus and chlorophyll a and suspended solids was observed by Fidalgo (2002) in the riverine sampling site located near fish farm outlet discharge. Nevertheless, such effects were not persistent for a long distance downstream. Since the "modus operandi" of this facility did not change in time it is expected that mentioned effects still occurring, nowadays. Besides, mainly in summer, when water temperatures are higher, fish mortality in outdoor tanks can be significant. Recently, in a very preliminary way, FWI and fluctuating macrophytes were placed the tanks to create refuge for fish and to control water temperature in summer (Fig 4). Crispim et al (2009) verified that macrophytes and root associated biofilm could be a valuable to preventing eutrophication in small-scale fish farming. Therefore, the implementation FWI in Castrelos should be design both in order to create adequate refuge for fish and to effectively remove the nutrient excess, preventing negative impacts in water quality of tanks and in Baceiro River. Nevertheless, before FWI implementation research should be carried out in order to evaluate:

a) The adequate macrophyte coverage area to effectively remove nutrients considering food requirements, fish density and N and P excretion rates;

b) The adequate macrophyte coverage area to effectively increase fish welfare;

c) How fish can influence the growth of plant root associated biofilm;

d) The efficiency of the combination of submerged and /or fluctuating plants with FWI.

The expected outcomes with the FWI installation are the reduction in mortality and the increase of fish condition due to the improvement of water and habitat quality leading to better levels of welfare.

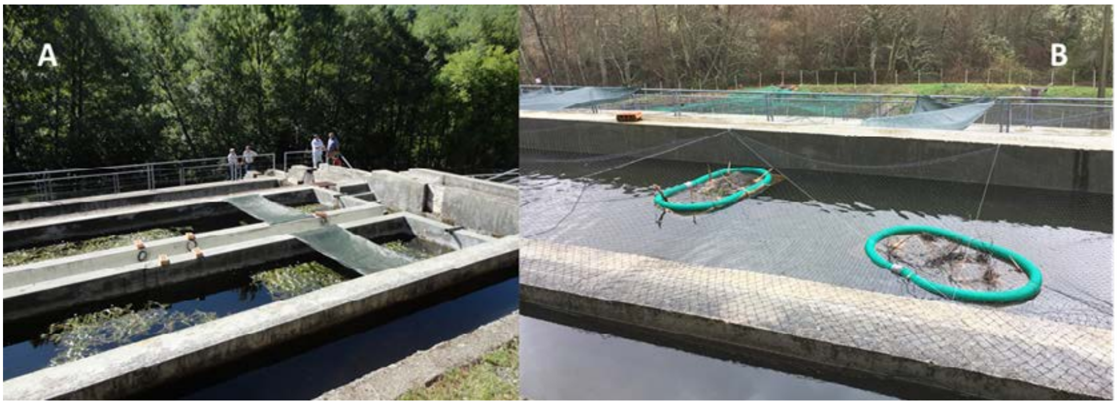

Figure 4: *Tanks with fluctuating macrophytes (A) and (B) with FWI in February 2021.*

CONCLUSIONS

FWI are nature-based solutions that provide an array of ecosystem services, and are characterized by being multifunctional. As both case studies had shown, FWI can be used in different scenarios, being extremely flexible technologies, assisting to the sustainable water resource management, uploading the depuration capacity, improving water, habitat and landscape quality and ultimately promoting biodiversity or, in case of fish farming, fish welfare. Nevertheless, there is still lack of knowledge concerning ecological fundamentals of aquatic ecosystems and fact that "each aquatic ecosystem has its own nuances" can limit the use and the efficiency of this technology if previous research and good monitoring design are absent.

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	AUDITORIUM B
	TECNOLOGÍAS INNOVADORAS
	Moderador: Carlos Aragón PhD. Confederación Hidrográfica del Tajo.
09:00-09:20	**METland® TECNOLOGY: WASTEWATER TREATMMENT IN SMALL COMMUNITIES** ***Abraham Estéve Núñez PhD. Universidad Alcalá de Henares. IMDEA Agua***
09:20-09:30	LOW COST WASTEWATER TREATMENT IN ANAEROBIC PHOTOBIOREACTORS ENRICHED IN PURPLE PHOTOTROPHIC BACTERIA *Patricia Zamora . Departamento de Innovación y Tecnología. Aqualia FCC*
09:30 - 09:40	VALUATION OF SMALL DOSES OF H2O2 FOR SOLAR WATER DISINFECTION ENHANCEMENT *Azahara Martinez Gracía. Plataforma Solar de Almería-CIEMAT*
09:40 - 09:50	NOVEL DIRECT ULTRAFILTRATION SYSTEM ASSISTED BY COAGULATION-FLOCCULATION FOR SEWAGE TREATMENT *Luisa Vera. PhD Chemical Engineering and Pharmaceutical Technology Department. University of La Laguna*
09:50 -10:00	INTEXT project: HYBRID INTENSIVE -EXTENSIVE RESOURCE RECOVERY FROM WASTEWATER IN SMALL COMMUNITIES *Raúl Cano Herranz. FCC Aqualia.*

	AUDITORIUM B		CONFERENCE HALL 1
	HUMEDALES CONSTRUIDOS Y OTROS TRATAMIENTOS EXTENSIVOS (II)		**TECNOLOGÍAS INTENSIVAS Y ELIMINACIÓN DE NUTRIENTES**
	Moderador: Cristina Calheiros.PhD. Centro Interdisciplinar de Investigação Marinha e Ambiental.		Moderador: Juan Ramón Pidre Bocardo PhD. Fundación CENTA
10:00 - 10:20	**THE VERSATILITY OF CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT** ***Ana Galvao PhD. CERIS.Instituto Superior Técnico.Univeridad de Lisboa***	10:00 - 10:20	**RISKS IN SUSTAINABLE MANAGEMENT OF WASTEWATER TREATMENT PLANTS OF SMALL VILLAGES ASSOCIATED WITH THE OBJECTIVES OF NUTRIENT CONTENT REDUCTION** ***Pedro Tomás Martín de la Vega Manzano PhD. PROMEDIO. Dpto I+D+i. Consorcio para la gestión de los servicios medio ambientales de la Diputación de Badajoz.***
10:20 -10:30	ON THE ECOLOGICAL BENEFITS OF USING CONSTRUCTED WETLANDS FOR TREATING WASTEWATER IN SMALL URBAN AREAS IN A MEDITERRANEAN REGION *María Peña García. Grupo Global Omnium*	10:20 - 10:30	MEDITERRANEAN LIVING LABS FOR NON-CONVENTIONAL WATER REUSE AT LOCAL SCALE: MENAWARA PROJECT *Isabel Martín García PhD. Fundación CENTA*
10:30 -10:40	HE USE OF CONSTRUCTED WETLANDS FOR WATER RECYCLE IN THE KINDERBOERDERIJ DE UYLENBURG, AMSTERDAM. *Leticia Weber Oliveira. Faculdade de Ciências da Universidade do Porto*	10:30 -10:40	CONTROL SYSTEM FOR THE OPERATION OF THE FUENTEHERIDOS WWTP (HUELVA) *Modesto Pereira Villaseñor. Gestión Integral de Aguas de Huelva. GIAHSA*
10:40 -10:50	DEVELOPING A NEW DESIGN OF ANAEROBIC DIGESTER FOR THE TREATMENT OF RAW WASTEWATER IN COMBINATION WITH CONSTRUCTED WETLANDS *Marta Sánchez Núñez. Departamento de Química. Universidad de La Coruña*	10:40 - 10:50	EC ENVIRONMENTAL TECHNOLOGY VERIFICATION OF RICHWATER® MEMBRANE BIOREACTOR *D. Antonia Lorenzo. CEO BIOAZUL*
10:50 -11:00	SOIL AMENDMENTS TO IMPROVE NUTRIENT ATTENUATION IN VEGETATION FILTERS *Virtudes Martinez Hernández. IMDEA Agua.*	10:50 - 11:00	EVALUATION OF EFFECTIVE MICROORGANISMS (EM) IN THE PROCESS OF TREATMENT OF DOMESTIC WASTEWATER IN HIGH-ANDEAN CONDITIONS *Juan Eduardo Vigo Rivera. Universidad Peruana Unión*
11:00 -11:10	CONSTRUCTED WETLANDS FOR SMALL COMMUNITIES WASTEWATER TREATMENT IN IN THE PERUVIAN COAST *Vladimir León Menacho. Cátedra UNESCO de Sostenibilidad, Universitat Politécnica de Catalunya*	11:00 - 11:10	LIFE PHOENIX: INNOVATE COST-EFFECTIVE TREATMENTS FOR REUSING WATER AND NUTRIENTS FOR AGRICULTURAL APPLICATION IN SMALL COMMUNITIES *Carlos Sauco. FCC Aqualia.*
11:10 - 11:20	APPLICATION OF FLOATING WETLAND ISLANDS FOR WATER AND HABITAT PROMOTION IN TWO CONTEXTS: URBAN RIVER AND SMALL FISH FARM *Ana María Antão-Geraldes. Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança.*		
11:20 - 11:30	**COFFE BREAK**		

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	SESIÓN PLENARIA III: Experiencias y planes de futuro para la depuración de las pequeñas poblaciones en las regiones IDIAQUA
	AUDITORIUM B
	I) CASOS DE ÉXITO
11:30 -12:00	**30 Años en al Planta Experimental de Carrion de los Céspedes: Una Retrospectiva Apasionada.**
	Juan José Salas Rodriguez. Fundacion CENTA.
12:00 - 12:20	**Depuración en Pequeñas Poblaciones: la experiencia de NILSA**
	Gregorio Berrozpe Ullate. Director de Obras y Proyectos.
	II) VISIONES REGIONALES
12:20 - 12:40	**Región de Algarve**
	Paulo Cruz. Chefe de Divisão dos Recursos Hídricos Interiores. Administração da Região Hidrográfica do Algarve
12:40 - 13:00	**Región de Extremadura**
	Álvaro Jiménez García. Director General de Planificación e Infraestructuras del Agua. Junta de Extremadura.
13:00 - 13:20	**Región de Andalucía**
	Sergio Arjona Jiménez. Director General de Infraestructuras del Agua. Junta de Andalucía
	MESA DE DEBATE: La Depuración en las Pequeñas Aglomeraciones Urbanas. Retos de Gobernanza , Gestión y Tecnológicos.
	AUDITORIUM B
13:20 - 14:30	***Joâo Simâo Pires. Director Ejecutivo Parceria Portuguesa para Agua***
	Manuel Dominguez Limón. Director Ejecutivo. GIAHSA
	Joaquim Freire. Diretor de Exploração - Saneamento, Águas do Algarve, S.A.
	Pedro Tomás Martín de la Vega. Director I+D+i. PROMEDIO.
	Pedro Rodriguez Delgado. Presidente ASA Andalucía. Gerente Aljarafesa.