Ecological Value of Constructed Wetlands in a Natural Park

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Fig. 1 – Constructed Wetlands in Pineta Park

Introduction

Constructed Wetlands (CW) are used for the treatment of domestic wastewater in rural landscapes, where the traditional treatment options can be difficult to enforce, and/or too expensive. Two types of constructed wetlands are used: the free surface wetland (FS-CW), exposing the water surface to the air, and the subsurface flow wetland (SSF-CW), maintaining the water level below the surface of a gravel bed. While not all CW replicate natural ones, it makes sense to construct wetlands that improve water quality and, at the same time, support wildlife habitat.

Pineta Park, a natural park in Northern Italy, has created a mixed SSF and FS-CW (figure 1) for the treatment of wastewaters produced by a hamlet placed in a wooded area. The SSF-CW is the core plant, where the effluents of 150 Equivalent Inhabitants (EI) are treated after an Imhoff tank pre-processing. Two FS-CW ponds have been built after the SSF-CW, with the main purpose of being colonized by the local biological communities, especially invertebrates and amphibians. Thus, along with CW treatment efficiency, ecological value of FS-CW ponds has been monitored and compared with that of some natural ponds located in the area, to understand if CWs can be considered a useful part of the ecological network.

Methods

Water physical, chemical and microbiological parameters have been monitored monthly for a 6 months period to assess the CW efficiency. Samples have been collected along the CW in 3 different sites: before and after the SSF-CW treatment (IN and OUT SSF-CW, respectively), and after the permanence in the FS-CW ponds (OUT FS-CW). The same parameters have been also collected, with other environmental variables, in 6 natural freshwater ponds within 10 km from the CW. Ecological data has been assessed collecting macroinvertebrates from both the FS-CW ponds and from the 6 natural ponds and wetlands with a 500 μm mesh Surber sampler and using artificial substrates. Invertebrates have been counted and taxonomically identified. Taxa Richness (S), Simpson (c) and Shannon (H) Diversity Indexes have been calculated.

Results & Discussion

CW efficiency

The CW treatment led to high rates of pollution removal. Results have been even better than expected (Figure 2), if compared with literature, also because not all the EI are already being treated by the CW and, thus, water has longer residence time. Over 90% of COD and total nitrogen (TN) has been removed, as well as over 99% of ammonia nitrogen (NH4-N) and total phosphorus (TP). Escherichia coli removal resulted in a drop of more than 10^5 CFU/100 ml.

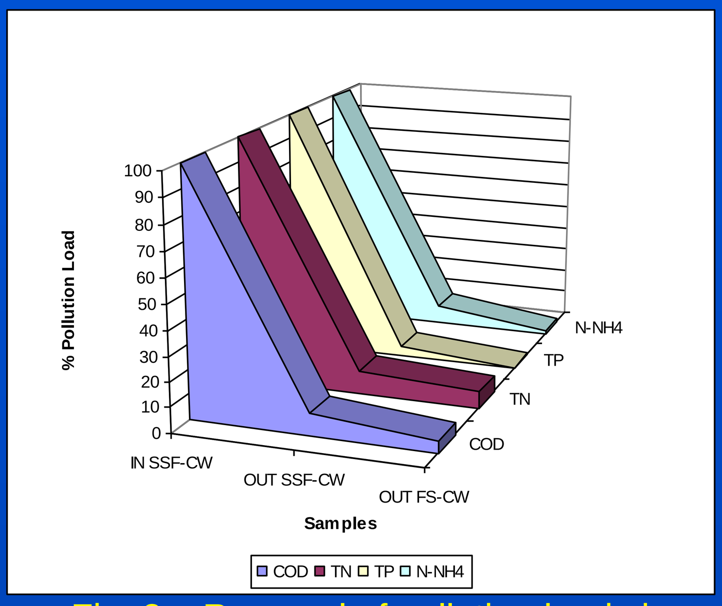


Fig. 2 – Removal of polluting loads in Pineta Park Constructed Wetland

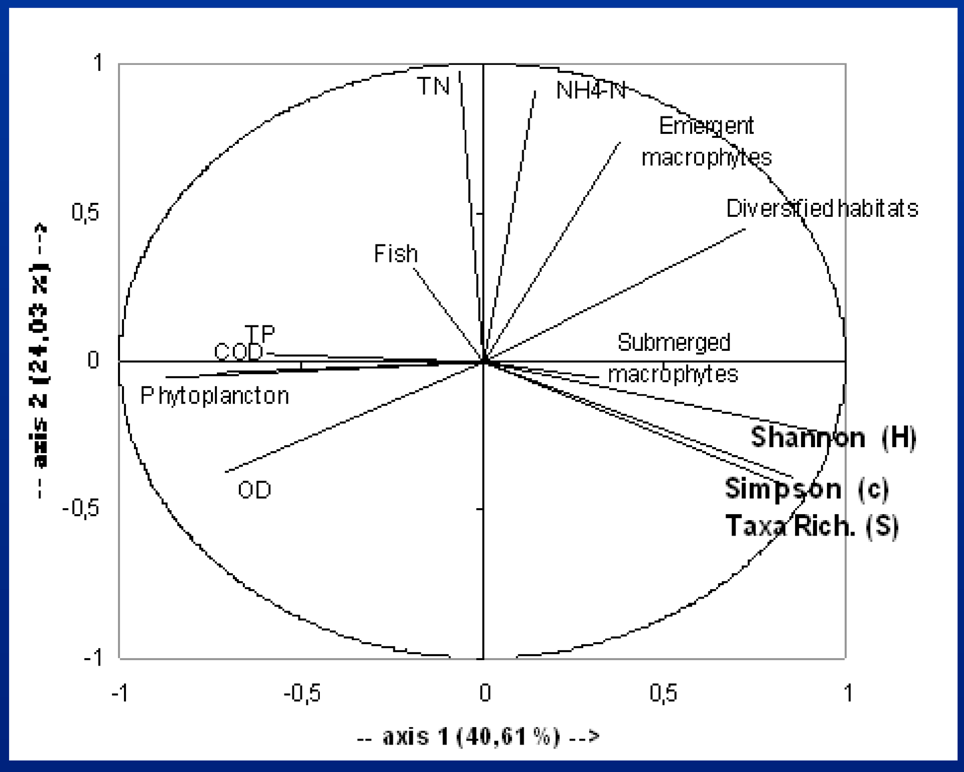
Ecological value

The ecological value of SF-CW ponds resulted high, if compared with the biodiversity of natural ponds (sites 1 to 6, Table 1). 14 taxa have been collected: 1 Ephemeroptera (*Cloeon*), 4 Odonata - figure 3 - (*Coenagrion, Ischnura, Libellula, Anax*), 4 Eteroptera (*Microvelia, Gerris, Plea, Hydrometra*), 1 Gastropoda (*Physa*) genera and 2 Diptera (Chironomidae, Stratiomydae) families. Compared with that of natural ponds (2 to 18 taxa, in sites 2 and 6 respectively), biodiversity of SF-CW (c=6,52; H=3,09) resulted lower only than that of site 6 (S=18; c=10,32; H=3,73).

Table 1 - Biodiversity of FS-CW and of 6 natural ponds sampled in the surrounding area.

	FS-CW	1	2	3	4	5	6
Taxa Richness (S)	14	8	2	13	5	9	18
Simpson Diversity Index (c)	6.52	4.54	1.08	4.60	4.26	6.12	10.32
Shannon Diversity Index (H)	3.09	2.46	0.24	2.80	2.20	2.86	3.73

Fig. 3 – Emergent Dragonfly adult on its larval skin at Pineta Park CW.



Principal Component Analysis (PCA) was performed in order to explain the characteristics of ponds presenting the higher biodiversity (Figure 3). Diversity Indexes resulted positively related with the presence of habitats and refuges (good morphology, submerged and emergent macrophytes) and negatively related with fish, pollutants and phytoplankton (related with high OD due to photosynthesis).

Particularly, Simpson Diversity Index presented significant ($p<0.05$, bilateral test) positive relationship with diversified habitats ($r=0.478$) and submerged macrophytes ($r=0.427$), and significant ($p<0.05$) negative relationship with phytoplankton ($r=-0.670$), COD ($r=-0.637$) and TP ($r=-0.446$).
Shannon Diversity Index presented significant ($p<0.05$) positive relationship with diversified habitats ($r=0.535$) and submerged macrophytes ($r=0.373$), and significant negative relationship with phytoplankton ($r=-0.898$, $p<0.01$), OD ($r=-0.601$, $p<0.05$) and COD ($r = -0.535$, $p<0.05$).

Fig. 4 – Descriptors plot along the first 2 principal axes of PCA analysis

Conclusions

Data collected and analyzed in Pineta Park suggests specifically that a "good" level of morphological and, thus, ecological diversity can be achieved by designing or placing:

(1) shady free-water areas, thus limiting phytoplankton blooms;
(2) submerged macrophytes in the free-water area;
(3) jagged riparian slopes with emergent macrophytes;
(4) various water depths within the pond.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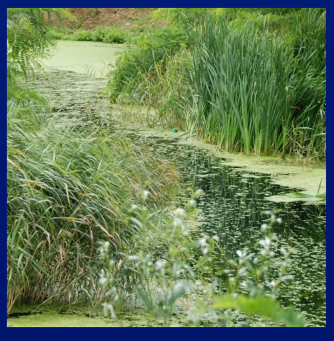
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Results show that, if removal of pollution is sufficient and if ponds are morphologically built providing diversified habitats to vegetation and animals, Constructed Wetlands can be valuable parts of the ecological network.

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