IMPORTANCE OF WETLANDS FOR WATER QUALITY AND A CASE STUDY OF EFTENI WETLAND-TURKEY AS A GOOD EXAMPLE

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Abstract

Wetlands are very complex ecosystems: they mainly have water bodies but include land as well. Interaction between water and land besides abiotic and biotic components is fundamental for treatment processes. Wetlands have a high, long-term capacity to improve every kind of water quality. They have been many initiatives for this purpose. Although the use of natural and pristine wetlands to assist in water purification has been in many points of the world for very long time, the constructed wetlands that are specifically designed for the treatment of wastewater (municipal, industrial, urban and agricultural) has become widely very new. Wetlands are important ecosystems that provide one of the richest biodiversity and buffer ecosystems. This study monitored the quality of surface water in the Efteni wetland system in Turkey, which is intertwined with the Melen River that is being considered to fulfill water necessity of important nearby cities.The results show that the wetlands and buffer zones had overall positive effect on water quality.

Key words: Efteni, natural wetland, treatment, water quality

1. Introduction

Wetlands are habitats for a wide variety of plant and animal life, especially water birds, and are also a nursery for several species of fish and shellfish and a variety of aquatic organisms (1, 2). Trace elements and other contaminants cause potential concerns in that they can be transferred and accumulated in the bodies of animals or humans through the food chain, with potential DNA damage and carcinogenic effects owing to their mutagenic ability (3). Wetlands remove metals using a variety of abiotic (physical/chemical) and biotic (microbial/phytological) processes (4, 5). Abiotic processes that immobilise contaminants include settling, sedimentation, sorption and chemical precipitation (1, 6-7). In biotic processes, macrophytes play the main role and can absorb pollutants in their tissue and provide a surface and environment on which microorganisms can grow (8 - 11). Moreover, they can carry out phytoaccumulation/phytostabilisation and phytodegradation/rhizodegradation (12).

Wetland plants are preferred over other bio-agents due to their low cost, frequent abundancein aquatic ecosystems, and easy handling. wetlands help in mitigating floods, recharging aquifers,

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and reducing surface runoff and the consequent erosion. The use of wetland areas as natural filters for the amelioration of pollutants transported in rivers or lakes is considered to be a successful, low-cost, cleanup option to ameliorate the quality of surface waters. Indeed, wetlands have been widely utilized in the last decades to cleanpollutedwateroveralmostall ‘theworld (13).

Wetlands can be considered useful buffer zones to protect surface water quality (14 -15). They have a high, long-term capacity to improve water quality and there have been many initiatives to restore them for this purpose (14). Due to their contaminant retention capability, constructed and natural wetlands have been effectively used in the U.S.A and Europe to reduce levels of copper, zinc, nickel, lead and other metals in runoff and drainage (12, 16-18). A number of studies have examined accumulation of heavy metals in natural riparian wetlands (NRWs) (19 - 20). Studies on the function of vegetation in wetlands have indicated that plant-covered wetlands may play a role in reducing heavy metals by storing them in various parts such as roots and shoots (21 - 22). The main purpose of this study is to investigate those wetland potential effects to water quality along with an example of the case study.

2. Utilization of wetlands in terms of water treatment and their potential

Water-resource managers worldwide are considering the potential role of riparian zonesand floodplain wetlands in improving stream-water quality. Site scale have demonstrated that wetlands have a high and long-term capacity to improve water quality and this evidence has resulted in many initiatives to restore or even create wetlands for this particular purpose.

Because of their high potential for nutrient retention, it is still a good idea to usewetlands incatchmentwaterresourcesmanagementforwaterqualityimprovement (14). In subsurface flow wetlands such as that represented on Fig 1, the flow remains below the surface, reducing odor and breeding sites for insect pests.

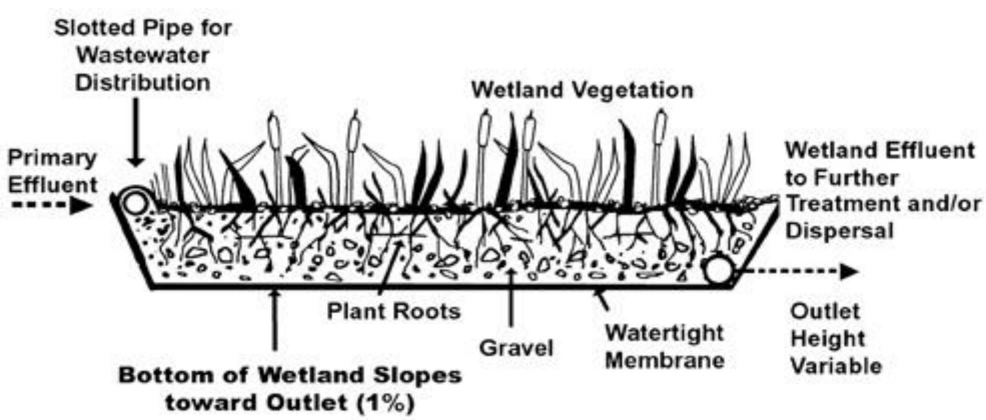

Figure 1. Constructed wetlands are artificially created ponds, resembling natural marshes or bogs, with a coarse media to support aquatic vegetation over an impermeable barrier (23).

It is founded that the riparian wetlands have a large capacity to retain heavy metals from upland and river water. Studies on the function of vegetation in wetlands also indicated that the plant-covered wetlands play an important role in reducing heavy metals by storing them in various parts such as roots and shoots (Canario et al., 2010).

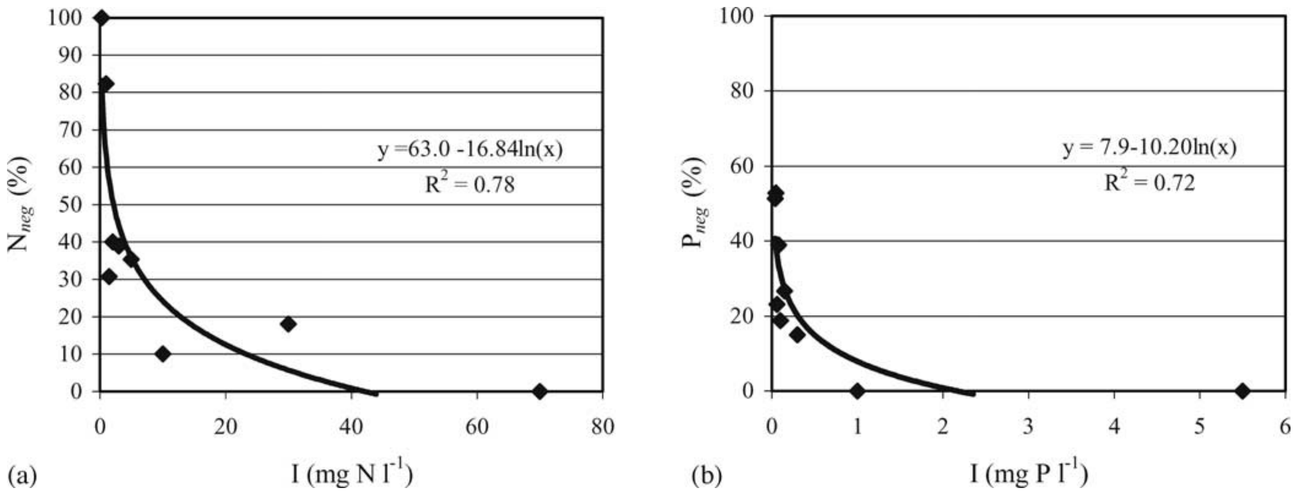

Fig. 2. The relation between input concentration (I, mgl−1) and probability of negative removal of (a) nitrogen and (b) phosphorus (Nneg and Pneg, %, respectively) (24 - 25).

There are quite a few studies reported CWs capability of treating heavy metals and persistent organic substances. Mechanism involved in heavy metal removal in CWs, includes a combination of sedimentation, filtration, binding to substrata, precipitation as insoluble salts such as sulphides or oxyhydroxides and accumulation by plants, algae, and/or bacteria (14).

Heavy metal translocation and bio concentration were varied in different plants species. In all the cases, contribution of below ground biomass (roots) contributed more in metal removal as compared to above ground biomass (leaves and stem). The concentrations of heavy metals in the wetlands show a similar order, i.e., soils > plant roots > plant shoots > water.

Table1Role of constructed wetlands in improving water quality (26)

Pollutant	Role of the Wetland
Suspended Solids and BOD	Sedimentation is facilitated by the vegetation. Finer particles adhere to the biofilm surfaces of the vegetation or the gravel substrate. Microbial degradation of organic particulates.
Nutrients	Direct uptake by plants and micro-organisms. Inorganic nutrients converted to organic biomass. Microbial processes facilitate the removal and transformation of nutrients, especially nitrogen removal.
Metals	Plant uptake and bioaccumulation. Microbial bioremediation. Immobilisation by adsorption onto sediments or by precipitation.
Hydrocarbons	Microbial hydrocarbon degradation.
Pathogens	Natural UV disinfection. Natural biocontrol by microbial predators in the wetland ecosystem. Adsorption to fine particles and sedimentation. Natural death and decay.

Generally, wetlands are known to perform very well as regards BOD5, COD and bacteria pollution reduction, but they show a limited capacity for nutrient (especially P) reduction. The high removal rate of BOD5 and COD is caused by filtration/sedimentation of suspended solids and bacterial oxidation. Results indicate an average removal of 76.8–99.8% (BOD5), 76.3–99.7% (COD) and 67–99.9% (NH4–N). The ranges of parameters in the effluent (mean ± SD) were: 12.3–38±9–39 mg/l for BOD5, 28–90±9–58 mg/l for COD, and 0.1–15±0.1–7 mg/l for NH4–N. It is noted that CWs are now being increasingly used for environmental pollution control in Ireland. At present, there are about 140 CWs in Ireland and most of them are local soil/gravel based systems with either horizontal or vertical flow planted mostly with common reeds (phragmitesaustralis) (27).

3. Situation of Efteni Wetland and its effect to the water quality

As a natural wetland, the Efteni wetland is important due to its location in the Melen watershed, which is located close to Istanbul and considered vital for its future water supply (Fig. 3). Although the benefits of wetlands for water quality have been clearly demonstrated, to our knowledge very few wetland studies have been conducted in Turkey or at other sites with similar climate and socio-economic development.

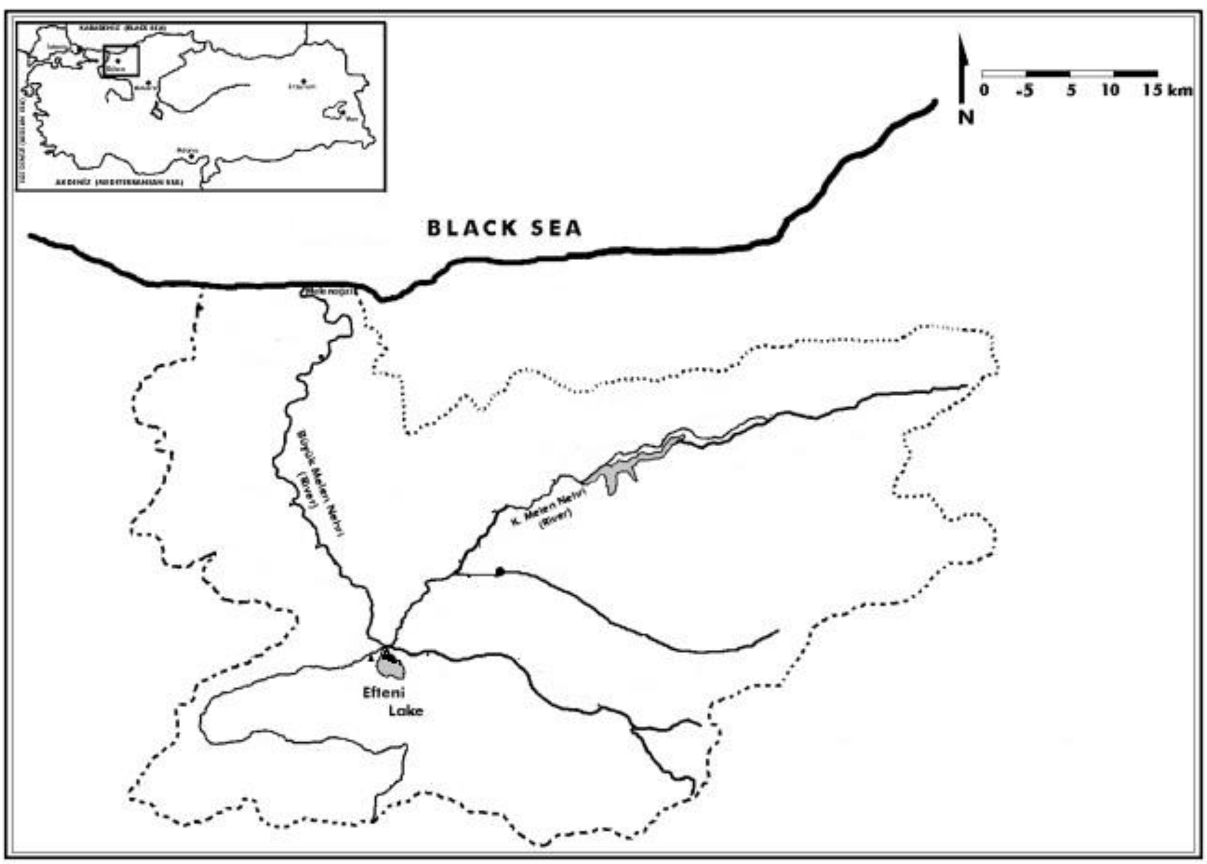

Fig. 3. Location of the Efteni natural wetland in the Melen watershed, Turkey (28).

The Efteni natural wetland is located in west-northern Turkey (41°5′-40°40′ N; 30°50′-31°40′E). The wetland collects most of the runoff water from a 10 km^2 sub-catchment of the Melen catchment (29). On leaving the wetland, the water flows to the river Melen and then on to the Black Sea. The former Lake Efteni had an overall surface area of 814.5 ha, but it was dried out to create a shallow lake and eventually a wetland with an area of 25 ha. Lakes were typically dried out as a precaution against malaria, in a trend which started in the 1950s. The KüçükMelen and two tributaries (Aksu and Uğursuyu) which joined the lake in the past were redirected to the BüyükMelen through diversion channels and thus the water volume in the lake greatly decreased (Figs. 3 and 4). The depth of the current wetland is 1-2 m and the trophic level is mezo-eutrophic (30 - 31).

Efteni Lake has ecological and ortinological importance because of its location on migration routes of birds. The region is established as “Water Birds Protection and Breeding Area”. The protection area is covered by 27.5% water, 38.1% meadowandthe rest 34.4% agriculture (32). Efteni Lake had an overall surface area of 814.5 ha in the past; it has been dried and converted into a wetland of 25 ha. Lakes were dried as a precaution against malaria as a result of an aptitude which started in 1950’s (30 - 31).

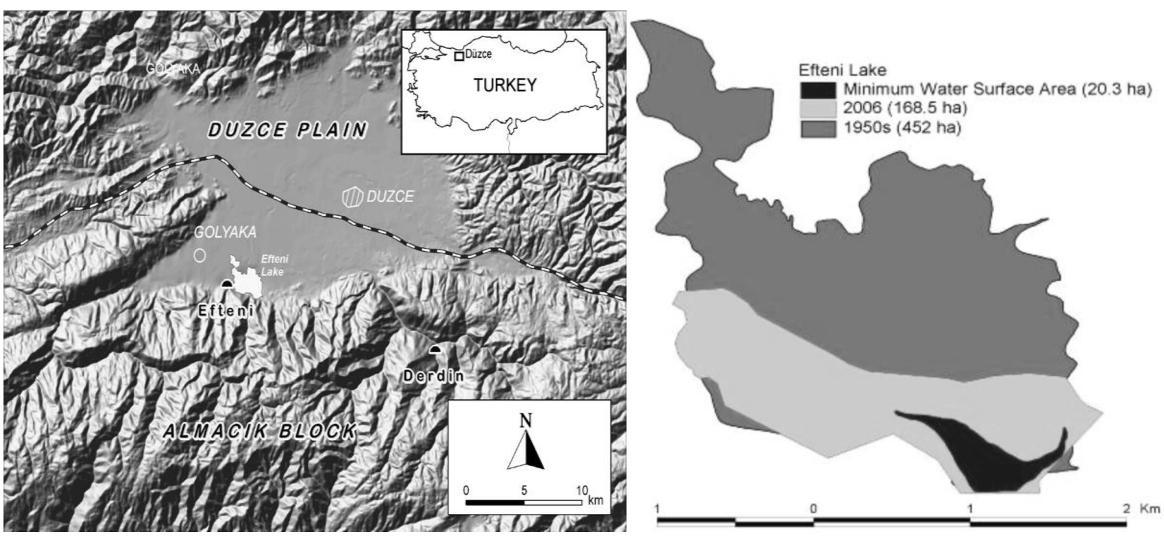

Fig. 4. Location of the Efteni area in northwestern Turkey (33) and widest boundaries, existing boundaries and minimum surfacearea of theEfteni Lake (31).

Surface water in the Efteni wetland was monitored at 7 locations; 4 inlets, 1 outlet and 2 locations inside Lake Efteni (Fig. 5). Monitoring of surface water trace elements was carried out in 2011 over three different vegetation transition periods from spring, summer and winter. One sample was taken before flowering (November-April), one during flowering (May) and one in the full plant coverage period after flowering (June-October). These occasions were chosen to examine how the wetland reacts to surface water concentrations when under different vegetation covers.

HACH pH, dissolved oxygen concentration (DOC),electrical conductivity (EC) were analysed at the sampling site. The samples were filtered through 0.45 µm Millipore paper, acidified with supra-pure nitric acid to pH <2 and stored in polyethylene bottles. Vanadium (V) concentrations were determined according to EPA 200.7 and ISO 11885 using by ICP. Each sample was analysed with three replicates and multi-element standards were used.

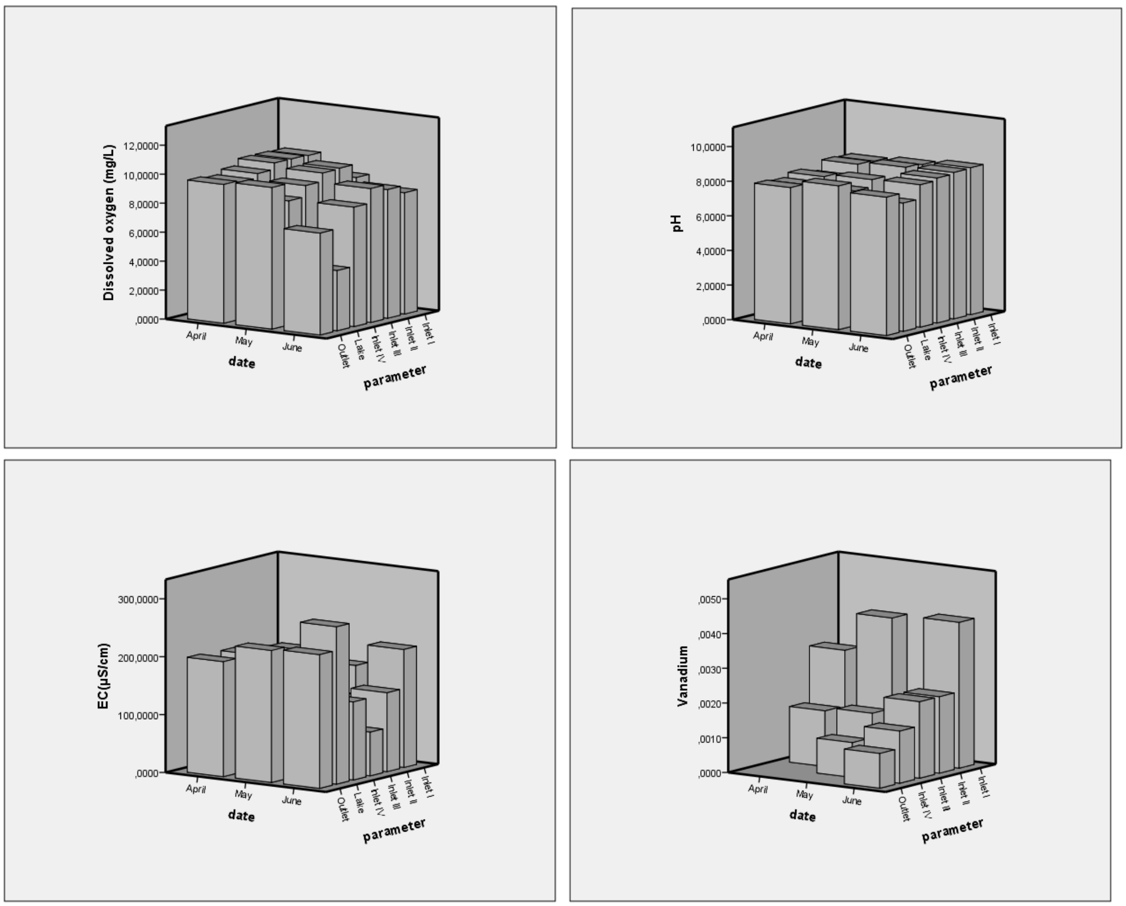

Fig. 5. Spatial and seasonal DOC, pH, EC and Vanadium concentration (mg/L) at different locations in the Efteni natural wetland in the different term.

TDS, EC, pH and DOC values varied spatially in the wetland. The highest TDS, EC and salinity values and the lowest pH, resistivity and DOC values were observed within the lake. The TDS, EC and salinity decreased from highest to lowest in wetland inlets in the order 1, 2, 4, 3. The situation was completely the reverse for DOC. TDS, EC and salinity were always higher at the outlet of the wetland than at the inlets, but lower than inside the lake. Regular changes in parameters between seasons showed that no acute contamination had occurred in the wetland. As selected trace metal Vanadium showed that different concentrations each inlet waters but in the end lowest concentration that proved natural purification.

Among the basic parameters, there was least fluctuation in pH (7.3-8.5). The pH value in the Efteni wetland area reached its lowest value at the end of the flowering period, at which time DOC amount reached its minimum level in the lake. As the flowering period approached, DOC decreased regularly (from 10 to 4 mg/L), probably due to consumption of dissolved oxygen by the metabolism of aquatic plants and algae.The minimum and maximum concentrations of dissolved oxygen are reported to be respectively directly related to the maximum and minimum amount of phytoplankton (33). In an idealised lake, the oxygen concentration in spring circulation is between 12 and 13 mg per litre (34 - 35) but the dissolved oxygen concentration in the Efteni wetland was occasionally lower, indicating pressure from eutrophication.

Conclusions

Wetlands have vast potential to purification all kind polluted water and needed use more in the earth. There was a clear effect of vegetation cover in the landscape on surface water quality in the Efteni wetland. Different stages of plant development (before, during and after flowering) provoked different responses in parameters, with a positive effect of wetland passage on elements. The biological richness of the wetland was very important, as it is in many other buffer zones. With its connection to the Melen River, an important water resource for the region, and its topographical structure, the Efteni wetlandoccupies a very important hydrological location. Inlet tributaries to the wetland were distinctly different from each other in terms of all parameters concentrations. The wetland showed clearly that being good example of water purification and positive effect.

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