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## A Review of the Riparian Ecosystems of Sperchios River, Greece

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**Abstract** The Sperchios River is the most significant river in Central Greece. It's located in a narrow valley; a plain pause in the mountainous area of the east Central Greece. This feature; the prevailing valley upon the shallow west Maliakos Bay, determined the historical importance and the modern challenges that the valley and its local ecosystems face. Its particular geology ruled the existence of the majority of the riparian ecosystems of Sperchios. From the patches and the narrow corridors of riparian vegetation in the upper Sperchios River followed by the immense riparian forest in the middle Sperchios River and then running the valley channelled and then ending to the west part of Maliakos Bay forming an important estuary, this mosaic in a river with a medium to small size, by any aspect either size or discharge, attracts the attention of environmental studies.

Considering the above features; justifies the extended literature, but not exhausted, about Sperchios and its adjacent areas. Environmental aspects of the area need to be revealed, especially the impacts and the interactions between the riparian ecosystems and the environment of the valley. Its evident the hydrologic impact upon the valley and the "health" status of the Bay due to the riparian ecosystems.

The aim of this paper is to record the previously published knowledge for the Sperchios riparian ecosystems.

**Keywords** Sperchios River, riparian ecosystems, riparian forest

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### 1. Introduction

The riparian ecosystems of Sperchios are located in Sperchios valley in Central Greece; the entire basin extends to an area of 1828 km<sup>2</sup> and a mean altitude of 636 m [5]. The main riparian ecosystems in the valley are the following: the riparian forests, the reed beds and the tamarisk-*Paliurus spina-christi* thickets. There is a lack of knowledge about the riparian ecosystems of Sperchios and generally about the riparian ecosystems in Greece; a consequence due to their small share in the entire area of Greece and until recent; their minor importance given by the state [1], [2].

The most notable feature of Sperchios, is the very high sediment yield and its severe flood water supplies [3]. Another feature but yet not well known is the plane-forest of Sperchios, still haven't been verified; is the largest forest of its species in Greece and probably the largest in the world, it extends to more than 950 Ha of pure and in mix stands [4, 5]. Also the original route of the river is modified close to its delta [6]. The construction of, the 9 km long diversion channel north of the old riverbed, in 1958 altered the dynamics in Sperchios Delta; forming a new Delta in the north and weakened the advance of the old Delta of the river [7].

### 2. Area of Interest

#### 2.1. Riparian Vegetation

The vegetation of the riparian ecosystems is mainly consisted by *Platanus orientalis* forming stands that are assigned to the *Platanion orientalis* and having reference code in the Palearctic classification is 44.71 [8]. These stands of *Platanus orientalis* cover a total area of 963,58 Ha; pure *Platanus orientalis* stands cover an



area of 714,30 Ha and 249,28 Ha in mix with *Populus alba*, *Alnus glutinosa* and *Salix sp.*, also occur scattered in our research area the following species *Pyrus amygdaliformis*, *Vitex agnus-castus*, *Tamix cretica* and *Nerium oleander* [4, 5, 9]. Besides the *Platanus orientalis* forest in the midcourse of the river, in the final part of the river we found *Tamarix sp.* thickets allied with *Paliurus spina-christi*, *Rubus sp.*, *Spartium junceum*, *Onobrychis sp.*, etc. and “wet meadows” (salt marshes and meadows) with key species in these meadows; the following *Juncus maritimus*, *Salicornia patula*, *Scirpus sp.*, *Hordeum sp.*, *Limonium sp.* [10].

## 2.2. Fauna

The riparian ecosystems of Sperchios are inhabited by many animal species either as residents or as visitors during their migration trip. The most important species occurring in Sperchios River and its adjacent areas are: *Pungitius hellenicus*; rare fish endemic of the valley, the reptile *Vipera ammodytes* included in Annex IV of the Directive 92/43/EEC. Also the presence of *Lutra lutra* (otter) it's been recorded; a species included in Annex IV of the Directive 92/43/EEC. Additionally in Sperchios estuaries and its riparian habitats host many migrating and resident species listed in Annex I of the Directive 79/409/EEC, indicative we mention *Branta ruficollis*, *Sterna albifrons*, *Anser erythropus*, *Egretta garzetta*, *Falco biarmicus* etc. [11]. A study about water pollutants and biochemical regime of many parts of the river claimed that the  $\text{NO}_2$  and  $\text{NH}_4$  are below the imperative values required for support of fish species and the phosphates are the main restricting factor of the phytoplankton growth [12].

In more detail about the avifauna; some families of bird species has been recorded in the estuary *i.e.* Ardeidae with main representatives Ardeacinerea and Ardeapurpurea, Anatidae reaching 18 species and the 10 of them occurring in large numbers, ranging from 2000 to 23000 birds, then we found birds of prey like *Circus aeruginosus*, *Circus cyaneus* and *Milvus migrans*, then we found 22 species of Charadriiformes ranging from 330-12050 birds, more important of them is *Recurvirostra avocetta* wintering in the estuary with a mean of 1300 birds, and the *Glareola pratincola* with 30-40 pairs [13].

## 2.3. Water

The River expresses a very seasonal flow from winter highs to summer lows, common floods and variable sediment yield. The major tributaries of Sperchios are the east and west Vistriza, Roystianitis, Loygies, Katis, Asopos, Palaiokastro stream, Gorgopotamos and Ipati stream, sourcing from the surrounding mountains of the basin; Tymfristos, Vardousia, Othrys, Oiti and Kallidromo [14]. The average overflow of Sperchios is  $693.1 \text{ hm}^3$  [15]. Also the entire basin counts 519 springs and the watercourse is contributed by 63 streams with permanent and intermittent flow [3, 15]. In the final part of the river, the deltaic area of Sperchios, we find 3 aquifers, the first is found in depth between 8.5 to 12.10 m, deeper we found artesian aquifers ranging in depths 53 to 71 and from 280 to 292 m [16].

Various physicochemical parameters display values within the expected ranges for a Mediterranean freshwater body with moderate human pressures. Particularly, the pH fluctuates between 7.8 and 8.2 while conductivity illustrates high average and maximum values, which is attributed to the coastal sampling locales that are strongly affected by the seawater. In the central and upper parts of the Sperchios basin are always below  $700 \mu\text{S/cm}$  and the dissolved oxygen levels are in general high (with the exception of two sites, the first is downstream of the confluence of Sperchios with Vistriza and the second is located at the confluence of the old river course of the River with Gorgopotamos, that they illustrate values lower than  $3 \text{ mg/l}$  during summer months). Also the recorded water temperature has a mean value of  $19.52 \text{ }^\circ\text{C}$  and ranges from a minimum of 10.41 to 28.9 maximum [6].

## 2.4. Geology

Sperchios basin is outlined by the following mountains, Tymfristos, Othrys, Oiti and Vardousia from the west, north, south and southwest respectively. The west part of Sperchios basin is dictated by flysch an impermeable rock formation, in the north and north-east mountainous part of the basin the majority of the bedrock is still flysch and igneous rock either impermeable or semi-impermeable bedrocks, in the east of the basin and in the lowland area are consisted of permeable geologic formations of karstic formations and recent deposits of Sperchios riverbed respectively, in the south the mountain of Oiti is mainly consisted of limestone [3]. The



deltaic alluvial part of the valley covers an area of nearly 200 km<sup>2</sup> and it's constantly formed with a distinct rate in entire Greece. The rate of expansion upon sea is nearly 13 Ha per year [16]. The total soil erosion in the basin fluctuates among 2,308,000 to 1,500,000 tones per year; the erosion occurs mainly in the bedrock formation of the mountainous regions of the Sperchios watershed [17].

## 2.5. Human activities

The agricultural sector rules the current status of the river; levees constrain the riparian areas in most of its length minimizing the floodplains of the river, agricultural drainage systems increase the leakage of agrochemicals and fertilizers to the river and eventually to Sperchios estuary. It's been estimated to 22,700 tones of fertilizers and 306 tones of pesticides. Effluents from industries and villages end in the river [11], [12]. Also the total acreage of irrigated crops (maize, cotton) was found reaching 42 km<sup>2</sup> by Psomiadis *et al.* [18].

The city of Lamia is operating a sewage treatment facility since 1994 and discharges in a Sperchios ditch (Germaniki Tafros) [15]. Also several weirs are built in Sperchios and its tributaries. Dimitriou *et al.* recorded values of NO<sub>3</sub> averaging in 3.4 mg/l and reaches 8.8 mg/l which imply that there are significant pressures from human activities. The fluctuation of NO<sub>3</sub> along the course of the river reaches higher values in the central and upstream of the parts of the basin where agricultural activities are intense, while lower values are recorded towards the deltaic area due to the biochemical regime that consume oxygen and transform NO<sub>3</sub> to NH<sub>4</sub> [6]. Another study classified Sperchios as a river with poor nutrient status [12].

It should be noted that a significant element as far as the changes in geomorphological evolution and the hydro-geomorphological processes of the delta area is concerned, is the rearrangement-partial diversion to the north, of the main bed of the Sperchios river and the construction of both, the old national road of Athens-Lamia, the new motorway and the new railroad. More detail, in this Delta area, from the year 1945 onwards, a period in time where appear the early human interferences in the area (national road Athens-Lamia, drainage and irrigation canals, etc). The construction of the artificial partial diversion to the north, of the Spercheios river channel was completed in 1958. The artificial diverted river channel is approximately 9.0 km long, 20 m wide and protected by two parallel embankments spaced 60 meters (Figs 1a & 1b). In 2007, started the engineering works to improve Sperchios diverted river channel for the stream discharge of peak flow (flood events), in Maliakos Gulf. Constructed a special construction (distributor) for the diversion of the stream discharge, while the channel was dredged (Figs 1c & 1d). The continuous flow of drain age in the Sperchio sold riverbed (Alamana) guaranteed by the southern embankment culvert up stream of the distributor with the bottom level below the crest over flow [7].



Figures 1a, 1b, 1c & 1d: The old and new delta of the Sperchios river in Maliakos Gulf. Rice cultivation in Spercheios delta area. Sperchios valley and its deltaic ecosystem is an important ecosystem in Greece and is included in the NATURA 2000 network (Code GR2440002 & GR2440005) (Fig. 1a). The new riverbed (artificial channel) of Sperchios (Fig. 1b). A special construction (distributor) for the artificial diversion of the Spercheios stream discharge of peak flow (flood events), in Maliakos Gulf (Figs. 1c&1d). (Photos by Mertzanis A.).

## 2.6. History

Located in the center of Greece, the valley witnessed many historical events, from the Battle of Thermopylae in 480 BC to the Battle of Sperchios in 997 AD between Byzantines and Bulgarians and the most recent the sabotage of Gorgopotamos viaduct during the operation Harling in November of 1942 that disrupted the supply chain of the German troops in North Africa.

## 2.7. Problems

The major problems of Sperchios deriving from the human interference to the river; levees, untreated effluents from local olive mills, the ineffective operation of sewage treatment facilities, illegal landfills located near river, that receive from locals construction debris, agricultural by-products and wastes located near river [16]. Dasenakis et al. found that major pollutants like polycyclic aromatic hydrocarbons were below detection limit, pesticides were found i.e. Atrazine, Prometryn, Chlorpyrifos-Me, Chlorpyrifos-Et and Alachlor but their values were below toxic levels. Finally metals such as Cadmium (Cd), Zinc (Zn) and Copper (Cu) were found below EU acceptable levels for water bodies that are fish habitats [12]. A general concern about the entire valley affecting consequently and the riparian ecosystems, were described by Psomiadis (2005), over a period of 23 years there were occurred significant changes i.e. intense urbanization especially in the largest municipalities (Lamia, Anthele, Antheleetc) and in coastal zone, the rapid expansion of croplands in expanse natural vegetation and the transition of winter crops to summer water demanding crops and vice versa depending on EU subsidies regime, the withdrawal (due to wildfires, encroachments of forested areas) of forest areas, the removal of natural vegetation especially in the riparian sites of Sperchios [18-19].

## 3. Conclusion

The research regarding the riparian ecosystems of Sperchios still lacks of detailed results, most of them are inventories and sections in Management Plans. The hydrology-environmental problems of the valley, still attracts the scientific interest followed by the geology, although the challenges and the functions that these ecosystems face and offer respectively, need to be revealed.

We retrieved more than 160 publications, in fact 166 published articles. The Fig. 2 shows the evolution of publications for Sperchios river to the last 65 years (from 1950 to 2015) [20].

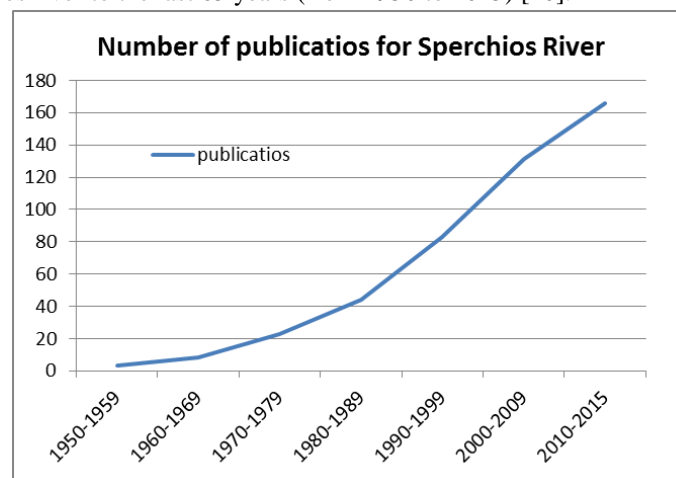


Figure 2: Evolution of publications for Sperchiosriver [19]



In detail we could suggest that we should develop regular monitoring programs about certain biochemical factors, there are contradicting data from different researchers and the water quality regime should be clarified. The importance of Sperchios for the migrating and resident birds still is under study, but the current knowledge show that the riparian areas and the estuary hosting many important species and numbers of migrating birds.

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