FACT SHEET: Pinios River Basin

The Pinios (aka Pineiós) River originates from the Pindus Mountains and then travels through the plain of Thessaly (Greece) until draining into Aegean Sea. The basin drainage area is of approximately 10,701 km^2. The Thessaly plain is the most productive Greek agricultural region. More than 50% of Thessaly is covered by agricultural land (51.7%); the other main land uses are urban areas (2.5%) and forest (45%). The main crops are winter wheat, maize, alfalfa, and cotton. More than 50% of agricultural land is irrigated, and irrigation for agriculture takes up 90-95% of the total water use (Psomas et al., 2016).

Figure 1. Pinios River drainage basin.

Table 1. Pinios River Basin characteristics

Pinios
COUNTRIES: GREECE
Pedo-climate: Southern region, Mediterranean South zone
Drainage Area 10,701 km^2
Maximum altitude: 2792 m
Annual average rainfall 512 mm/year
Main land uses: Agriculture 51.7%; Forest 45%, and Urban 2.5%
Population in 2015: 544,637
River length 229 km
Strahler Order – 7
Discharge at outlet 25.3 m^3/s
Outlet coordinates: 39° 56’ 3’’ N, 22° 43’ 3’’ E

The plain of Thessaly is a Nitrate Vulnerable Zone (NVZ) under Nitrates Directive. According to the Water Framework Directive 1st River Basin Management Plan, the majority of water bodies were characterized as less than good. The deltaic plain of Pinios River supports great biodiversity of flora and fauna of significant ecological importance, and designated as “Special Protection Area” of NATURA 2000 network (GR1420015) and a CORINE biotope (A00020006). It includes riparian forests, an estuary with riparian woodland, marshes, small freshwater lakes, sand dunes and the coastal zone.

Agriculture and water in the Pinios Basin

In the Pinios basin, agricultural activities exert large pressures on the groundwater resources. Better management of fertilization is recommended (Fytianos et al., 2002; Stefanidis et al., 2016). The study of Dimopoulos et al. (2003) was conducted in western Thessaly over an area of 740 km^2, 478 km^2 of which is cropland. Nitrate concentrations measured in 14 deep wells in 2002 were very high (average values 435 μg N/L in May and 734 μg N/L in August), and exceeding at times the Maximum Admissible Concentration of 800 μg N/L. Groundwater in the study area was found of medium quality; in about 40% of wells, water was not drinkable due to high nitrate concentrations. High concentrations of nitrite and ammonia measured in May were attributed to fertilizer application. An additional impact of agriculture to groundwater is the decline of the water table. The expansion of the irrigated area, which increased from 105,000 ha in 1977 to 242,447 ha in 1994, resulted in declines of water table heads from a depth of 2 to 5 m below ground to 10 - 15 m or more in the central parts of the basin.

As basin surface and groundwater bodies exhibit nitrate concentrations in excess (or a potential to exceed) of 50 mg NO_3^-/L, a dense network of groundwater monitoring was implemented to establish the extent of nitrate pollution from agricultural sources (Karyotis et al., 2002). An action plan was developed to address groundwater deterioration of the Pinios River basin,

aiming primarily to decreasing pollutant inputs. The plan identified three geological zones, from high, to moderate and to low vulnerability to nitrate pollution, for which flexible fertilization scenarios were designed. This plan included recommendations for nitrogen doses for cotton, maize, and sugar beets, suggesting curbing nitrogen fertilization by 50%, introducing legume cover crops in autumn-winter, and applying crop rotations. These measures were predicted to reduce nitrogen surplus by 30-35%.

Loukas et al. (2007) assessed potential of surface and groundwater resources by modelling demand of water sectors and water balance in the main sub-basins of Thessaly. Intensive cultivation of water demanding crops, such as cotton and maize, has led to a remarkable water demand increase, which is usually fulfilled by the overexploitation of groundwater. This over-exploitation especially during extended drought periods accelerated degradation of water resources, both in quantity (important decline of groundwater level) and quality.

Maniatos et al. (2018) researched conditions in the shallow aquifer system in the alluvial sediments, which are composed mostly of coarse-grained sands, with clays and silts at the river mouth area. The area is mostly cropland, including kiwi, olive trees, corn, sunflower, cotton plantations, but there are areas for animal grazing. The average nitrate concentration of the 48 groundwater samples was 6.2 (range 0.02-31.8) mg NO_3^-/L, whereas average nitrite concentration was 0.05 (range 0.001-1.2) mg NO_2^-/L, the average ammonia concentration was 6.2 (range 0.007-89.7) mg NH_4^+/L, likely linked to domestic or industrial waste, and average phosphate concentration was 0.5 (range 0.003-4.5) mg PO_4^{--}/L. These results indicate that the water quality was good compared to other river delta worldwide, but river and groundwater were susceptible to nitrogen contamination, especially from agricultural practices and point sources pollution.

In another study in the deltaic plain of Pinios River, Pisinaras et al. (2014) showed that between 1998-99 and 2013, median nutrient concentrations have decreased substantially, indicating an improvement in the deeper aquifer. The improvement of water quality has been attributed to changes in crop types, i.e. the substitution of high-water consuming with less water demanding crops. Local land uses have changed considerably and groundwater abstractions for irrigation have been substituted to a significant degree by abstractions from surface water of the Pinios River. Unfortunately, in the same period, sea water intrusion in the shallow and especially in the deep aquifers resulted in increasing chloride concentrations. In a follow-up work (Pisinaras et al., 2015), the impact of agricultural and touristic activities on groundwater quality of the phreatic and deep aquifers of the region was assessed. In 2013-2014, the nitrate concentrations of the phreatic aquifer averaged 8.1 (median of 2.8; range 0.0-38.0) mg NO_3^-/L. Concentrations in the deeper, confined aquifer averaged 7.4 (median of 3.1; range 0.4-37.3) mg NO_3^-/L. Despite increased pressure from agricultural pollution, the levels of nitrates in the groundwater remained low primarily thanks to local reducing conditions in aquifers.

Stamatis et al. (2011) studied the northeast and southern parts of the Pinios River basin groundwater and springs. The authors demonstrated that degradation of groundwater quality is connected to the intensification of agriculture, the unreasonable use of chemical fertilizers, and over-abstraction driven by irrigation demand, which exacerbates the problem of nitrate pollution.

Impact on coastal areas

Nitrogen loadings to the coastal zone, however, appear for now not in excess of silica loading, probably due to a large denitrification both in ground water and riverine bottom sediments, as well as in ditches and canals. This nutrient balance (and related ICEP indicator, Billen and Garnier, 2007) would prevent any risk of eutrophication at the marine coast. Similarly, no risk of coastal eutrophication is expected from phosphorus. This, coupled with the relatively high flush rate and short residence time, reduce risks of eutrophication in the coastal zone.

In conclusion, scientific literature demonstrates the extent of groundwater overexploitation and nitrate pollution in relation to agriculture. This body of evidence justifies the designation of the plain of Thessaly as a Nitrate Vulnerable Zone (NVZ), and testify the pressure of agricultural activities on the chemical and ecological status of the basin water bodies.

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