

The Uncontrolled Growth of *Azolla* in the Guadiana River

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The Guadiana River is an international one that has its spring in Spain (Campo Montiel) and its mouth between Ayamonte and Vila Real de Santo António (Algarve, Portugal). The basin area of the river is about 67,000 km², of which 12,000 km² are in Portuguese territory. In 1990-1993, southern Portugal experienced low rainfall with long dry seasons. This factor, combined with several dams along the river, caused low water flow during 1993. In addition, farming and industrial activity in the upper area of the Guadiana, together with untreated domestic effluents from several towns and villages, contributed to organic contamination of the Guadiana River that year. Lower flows (3.64 - 1.13 m³/s) also promoted higher nutrient concentrations. Maximum *Azolla* growth requires a phosphorus level of over 0.4 mg/L. At different river sites during the first months of 1993, the phosphorous levels changed, with maximum concentration values in April between 5.36 and 0.63 mg/L P. In April 1993, a massive *Azolla* fern bloom occurred.

Azolla caroliniana normally exists in small channels or in restricted zones of the upper Guadiana River. In the lower Guadiana River, the bloom was composed of *Azolla filiculoides*. The number of sporulated plants in 1993 was >75%. This fact, associated with the high nutrient concentration in the river, allowed the fern to expand into new areas, ending with the explosive bloom observed in 1993. In some areas, *Azolla* covered the surface for several kilometres along the river. The situation was the worst near the village of Mértola and produced panic among the population, especially the fishing community. Fishing was difficult and the fish caught could not be sold due to local suspicion that it was poisoned.

The explosive growth of the *Azolla* represented the first occurrence in Portugal of such a large scale uncontrolled growth of this fern in a river. As a consequence, governmental authorities took a special interest. Aerial photographs of the river were taken to document the extent of the coverage and military forces were brought in to control and isolate the area. The situation grew into a national event with intense media coverage. Unfortunately, some of the news reported was incorrect or exaggerated, contributing to the panic of the population. Decisions by the government to remove the *Azolla* were rash and without scientific support. In the first removal efforts made by the local and military authorities, large amounts of the fern were harvested and placed on the river banks to dry. A large quantity of juvenile eels (*Anguilla anguilla*) were found in the harvested biomass, which was a cause of great concern. Apparently, the *Azolla* bloom had coincided with the migration of juvenile eels in the river. Due to concern that the fern biomass, which covered large areas of the river, could cause eutrophic conditions, a monitoring survey of the main water quality parameters was done and the *Azolla* biomass was removed in the most problematic areas.

The catastrophic event ended with the closing of the life cycle of *Azolla* and the disappearance of its vegetative structure. However, the incident left an important message for our environmental authorities who need to examine weed management in Portugal. The way a civil population can react to an unusual ecological situation and how the media can contribute to the amplification of the situation, perhaps leading to panic, are important points to be considered for management models developed in the future. All of these events reinforce our belief that only with monitoring and prevention, involving central and local authorities with an adequate environmental education, can we solve future problems like those experienced in April of 1993.



Map of the *Azolla* bloom on the Guadiana River in Portugal.



View of the *Azolla filiculoides* "carpet" covering the water surface near Mértola, Portugal.