From Early Warning to Biodiversity Discovery: Integrated Monitoring of Italian Coastal and Inland Waters with Insights from Bagni San Filippo

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A coordinated monitoring effort in Italy demonstrates that satellite-guided sampling integrated with high-resolution chemical and biological analyses can provide an effective early-warning system for cyanobacterial blooms and their metabolites, while expanding knowledge of cyanobacterial biodiversity. Current activities target coastal waters along the Italian coastline and selected inland environments, including regional monitoring across Campania, with numerous sites sampled, among which Bagni San Filippo (BSF) is included. Cyanobacteria, due to their adaptability and capacity to produce bioactive and potentially toxic metabolites, are investigated as bio-indicators of environmental quality and as sources of chemically diverse compounds. The main objectives are to detect bloom events and associated cyanotoxins, characterize taxonomic diversity, and assess implications for ecosystems, human health, and the food chain.
This approach relies on a Fast Detection Strategy (FDS), combining satellite imagery to guide sampling with microscopy and high-resolution LC-MS coupled to molecular networking for rapid metabolite annotation, supported by cultivation under OSMAC conditions to explore shifts in morphology and metabolomic profiles. To date, 27 seawater samples have been collected under bloom and non-bloom conditions, alongside nine regional sampling events (January-July 2023), during which cyanobacteria belonging to genera such as *Microcystis*, *Leptolyngbya*, and *Lyngbya* were identified microscopically, while chemical analyses are ongoing.
Within this framework, the geothermal site of BSF provides a case study highlighting the value of inland extreme environments. Here, the novel cyanobacterium *Tusconia apicata* gen. et sp. nov. (TBCL 2401) was characterized through a polyphasic approach integrating morphology, pigment composition, and 16S rRNA phylogeny supported by ITS analysis. Chemical profiling revealed a carotenoid-rich extract with anti-inflammatory activity and a phycocyanin-rich fraction with antioxidant properties. Notably, no cyanotoxin biosynthetic genes were detected.
Overall, integrating large-scale coastal monitoring with targeted inland studies supports a dual strategy that is both risk-oriented and discovery-driven, while emphasizing the need for harmonized sampling and reporting.