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Review

Non-perennial Mediterranean rivers in Europe: Status, pressures, and challenges for research and management

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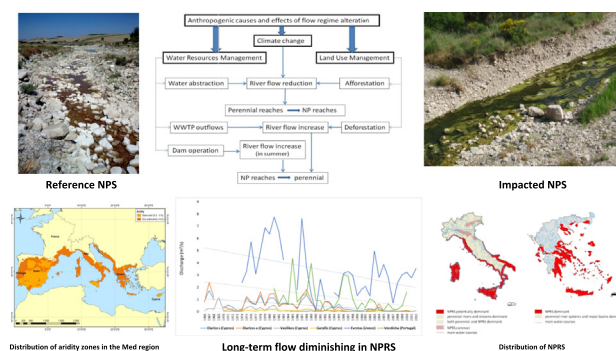
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HIGHLIGHTS

- Low precipitation and increasing water demands in the EU-Med area have created artificial non-perennial rivers and streams.
- NPRS are particularly vulnerable since they lack adequate protection and management.
- To combat artificial drying, we need to define alternatives to existing irrigated farming practices for EU-Med countries.

GRAPHICAL ABSTRACT



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ABSTRACT

Non-perennial rivers and streams (NPRS) cover >50% of the global river network. They are particularly predominant in Mediterranean Europe as a result of dry climate conditions, climate change and land use development. Historically, both scientists and policy makers underestimated the importance of NPRS for nature and humans alike, mainly because they have been considered as systems of low ecological and economic value. During the past decades, diminishing water resources have increased the spatial and temporal extent of artificial NPRS as well as their exposure to multiple stressors, which threatening their ecological integrity, biodiversity and ecosystem services. In this paper, we provide a comprehensive overview of the structural and functional characteristics of NPRS in the European Mediterranean, and discuss gaps and problems in their management, concerning their typology, ecological assessment, legislative and policy protection, and incorporation in River Basin Management

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Plans. Because NPRS comprise highly unstable ecosystems, with strong and often unpredictable temporal and spatial variability – at least as far as it is possible to assess – we outline the future research needs required to better understand, manage and conserve them as highly valuable and sensitive ecosystems. Efficient collaborative activities among multidisciplinary research groups aiming to create innovative knowledge, water managers and policy makers are urgently needed in order to establish an appropriate methodological and legislative background. The incorporation of NPRS in EU-Med River Basin Management Plans in combination with the application of ecological flows is a first step towards enhancing NPRS management and conservation in order to effectively safeguard these highly valuable albeit threatened ecosystems.

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1. Introduction

Lotic freshwaters are either perennial or temporary (or non-perennial), according to surface flow conditions. Perennial rivers and streams (herein PRS) flow throughout the year, whereas temporary systems (herein non-perennial rivers and streams, NPRS) cease to flow at the surface for some time of the year. Depending on the specific flow regime, NPRS can be classified, according to the most common perceptions, as intermittent, ephemeral or episodic. Intermittent rivers cease to flow seasonally or occasionally (usually for weeks to months); Ephemeral streams flow only in response to precipitation or snowmelt events (days to weeks); Episodic streams carry surface water only during very short periods (hours to days), primarily after heavy rainfall events (McDonough et al., 2011; Arthington et al., 2014).

NPRS are among the most dynamic, complex and diverse freshwater systems (Larned et al., 2010; Acuña et al., 2014). They are located in all regions worldwide, and they are by far the most dominant river type in

arid and semi-arid areas (Larned et al., 2010; McDonough et al., 2011; Acuña et al., 2014). NPRS may account for >50% of the total length of the global river network, including low order streams (Datry et al., 2014a). In Mediterranean regions, NPRS are the dominant freshwater type (Tockner et al., 2009; Bonada and Resh, 2013). They encompass remarkable hydrogeomorphological diversity, including snow-melt and rain-fed headwater streams, spring-fed karstic rivers and streams, braided channel networks, as well as single-thread upland streams and lowland rivers.

NPRS provide habitat for a diverse and unique flora and fauna (Meyer et al., 2007; Larned et al., 2010; Bonada and Resh, 2013; Acuña et al., 2014). They function as biogeochemical hotspots that retain, transform, and transfer carbon, nutrients and particulate matter (Larned et al., 2010; McDonough et al., 2011; Bernal et al., 2013; Datry et al., 2014a). In Mediterranean cultures, “dry rivers” are very well-known in society, reflected by various popular names: *ribeiras* in Portugal, *arroyos*, *cañadas* or *ramblas* in Spain, and *rambles*, *torrents*, *rieres* and

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