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Analysis of structural and functional indicators for assessing the health state of mountain streams

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ABSTRACT

Mountain streams play a key role in the conservation of aquatic biodiversity and key ecosystem services; however human activities are threatening these ecosystems as mountain areas become more and more developed and intensively used. Many of these streams are not considered in current national monitoring programs due to their small catchment area. However, assessing their status and monitoring their trends is well needed to ensure their proper management and conservation. In this study, we evaluated the use of a range of indicators related to different ecosystem structural and functional components in 2 streams affected by sewage outflows and compared with an unpolluted stream in the Picos de Europa National Park (Spain). We surveyed benthic periphyton, macroinvertebrate communities and fish assemblages and also estimated periphyton growth rates, wood decomposition rates and river metabolism. Additionally, we compared the performance of the selected indicators in different hydraulic conditions. Results revealed an effect of the organic pollution on most of the functional and structural indicators for the most polluted stream. Only the number of Ephemeroptera, Plecoptera and Trichoptera taxa, the Iberian Biomonitoring Working Party index, the invertebrate multimetric index used by the regional water agency, the fish abundance and biomass were sensitive enough to detect low levels of pollution and followed the expected response to the pollution degree. Moreover, most of the indicators behaved similarly under different hydraulic conditions, without major differences between pools and runs. However, the combination of both pool and run replicates at the reach scale resulted in a higher detection capacity of the effects of organic pollution.

1. Introduction

Mountain streams are small in size but represent a large extension of the whole river network (e.g. streams of order 1 and 2 can achieve up to 60% of the length of many river networks; Strahler, 1957; Leopold et al., 1964). They constitute a unique set of habitat conditions within the river networks, characterized by fast flows, well oxygenated waters and low water temperatures. These conditions support a diverse set of organisms (Finn et al., 2011), some of which are unique to these streams, and serve as refuge for aquatic species that move into headwaters seasonally or at particular life history stages (e.g., for spawning or nursery areas). Furthermore, mountain streams receive high inputs of organic matter from the surrounding terrestrial environment (Rosemond et al., 2015), conferring them an important role in nutrient regulation and export to downstream river reaches (Peterson et al., 2001).

Mountain ecosystems are continuously threatened by human activities such as water extraction, channelization, logging, mining (Meyer et al., 2007) or river pollution from untreated wastewater derived from domestic, agricultural and farm activities (Lecerf et al., 2006). Impact trends on mountain ecosystems are increasing and are expected to increase in the proximate future due to the intensification of human uses on mountain areas worldwide (Wohl, 2006). Nowadays, there is specific legislation as the Water Framework Directive in Europe (WFD; 2000/60/EEC) or the "Clean Water Act" in the US (CWA; US Government 1977) that ensures the good status of aquatic ecosystems. Nevertheless, many mountain rivers are excluded from national or regional monitoring programs due to their small watershed area (many of them below 10 km^2). Moreover, official methods are commonly based on a reference condition approach, in which a single river reach estimate from a composite sample is contrasted with a reference benchmark without taking into account within site variability (see application of WFD in the EU, e.g., Bohmer et al., 2004; Ofenbock et al., 2004; Couto-Mendoza et al., 2014). This contrasts need robust spatial designs (e.g., control-impact) that generate solid statistical tests to infer whether river

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