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Response of macroinvertebrate communities to hydrological and hydrochemical alterations in Mediterranean streams

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ABSTRACT

Mediterranean rivers are affected by natural disturbances and human pressures, which may alter their hydrology, water quality and habitat structure. In this study an analysis of macroinvertebrates community structure has been used to determine how distinct human pressures, such as point and non-point sources of pollution, together with groundwater withdrawal, may affect these ecosystems. A total of 4 sampling campaigns were conducted in the middle reach of the Onyar River (NE Spain), which was affected by agricultural and urban uses. Stream discharge and physicochemical parameters were measured *in situ*, and water samples and macroinvertebrates assemblages were taken and properly preserved for subsequent analysis and identification. Variation partitioning showed that macroinvertebrate community structure was particularly dependent on hydrochemical characteristics, but also on hydrological variations. In addition, results indicated that groundwater withdrawal altered stream hydrology, and the main reach of the Onyar River became intermittent and even completely dry in downstream positions. This reduction on stream discharge caused changes in habitat characteristics, as well as in the proportion of wastewater. Some wastewater dilution occurred, linked to groundwater with high nitrate concentrations inputs to the stream, and even though the macroinvertebrate community recovered its quality in some sampling campaigns, it presented a different structure than in sampling points not affected by any of these pressures. Therefore, the approach here used to analyze the hydrological effects on macroinvertebrate communities allowed us to determine their influence on hydrochemical and habitat characteristics.

1. Introduction

Mediterranean rivers are characterized by a variable flow regime with dry summers and winters, and rainy springs and autumns. These ecosystems show seasonal and predictable disturbances such as floods and droughts (Bonada et al., 2007), and may be characterized by four different general flow categories, according to Boulton et al. (2000): (1) ephemeral (flow briefly, with irregular timing (< 1 month) and usually only after unpredictable rain has fallen); (2) intermittent or temporary streams (flow for longer periods (> 1–3 months), regularly have an annual dry period coinciding with prolonged dry weather); (3) semi-permanent streams (flow most of the year but cease flow during dry weather (< 3 months) drying to pools); and, (4) permanent streams (with perennial flow except for rare extreme droughts).

However, these ecosystems may be affected by different kinds of pressures which may alter stream hydrology, water quality and habitat structure (e.g. Allan, 2004; Theodoropoulus et al., 2015). Pressures on water quality can be classified according to their origin: urban and industrial wastewater discharges, whether treated or not, can be considered as a point type pressure that modifies surface water hydrochemistry. In addition, streams may be affected by non-point source pollution caused by surface and subsurface runoff from croplands and urban areas, which is seasonal and highly affected by climate variability.

Land use may not only affect stream water quality, but also hydrology and habitat structure. In Mediterranean areas, alterations on flow regime caused by water regulation, direct extractions or groundwater overexploitation reduce the quality of water, as well as its availability to support a functional aquatic ecosystem (Miller et al., 1989; Sánchez and Schmidt, 2012; Benejam et al., 2010; Menció et al., 2014). Therefore, these alterations may enhance the effects of droughts in these ecosystems. Depending on duration of dry periods, and the basin and reach characteristics, drought intensity may range from declines in discharge below average baseflow levels, to intermittency, and

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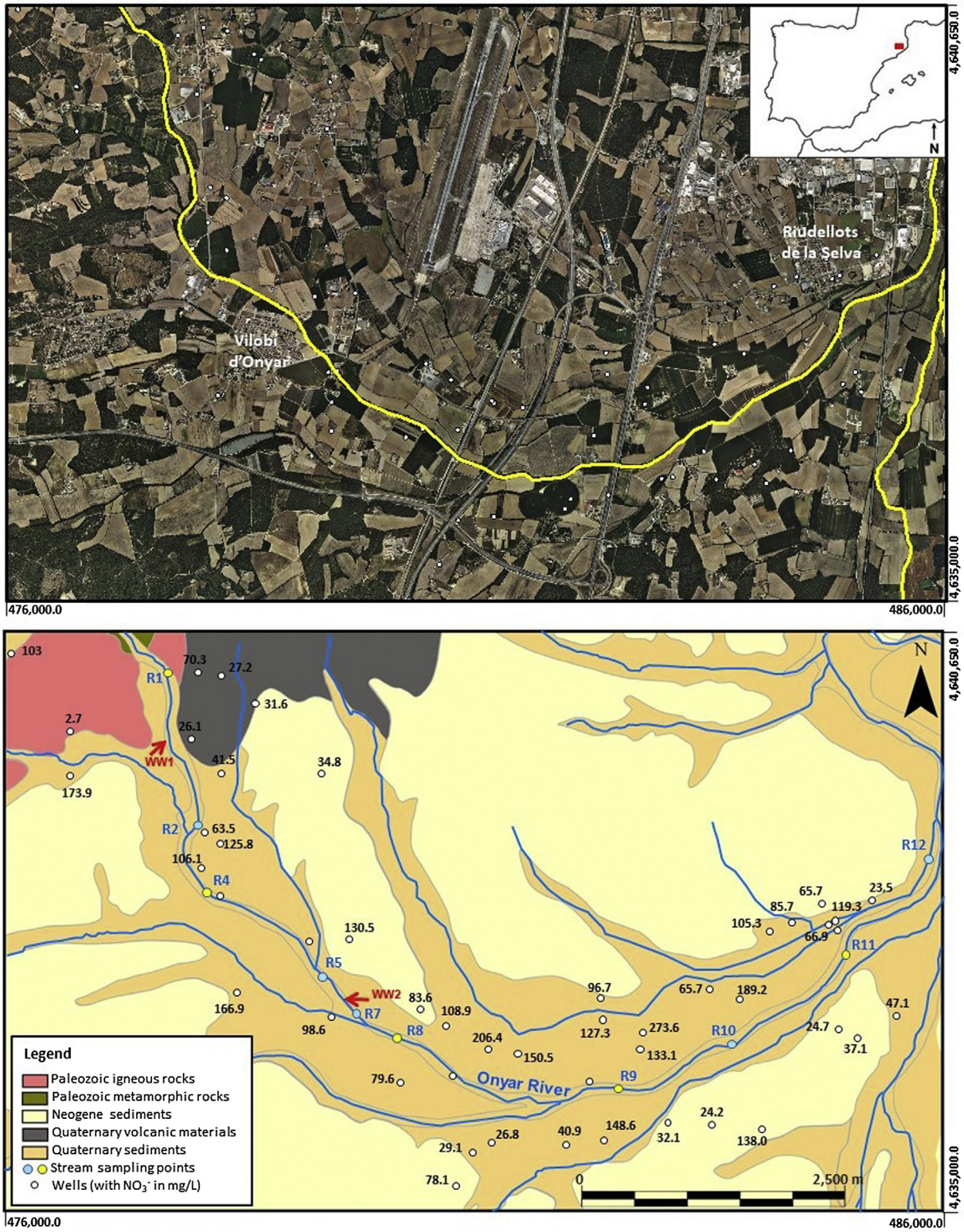

Fig. 1. Geographical and geological situation, as well as sampling points' location. Legend: WW, wastewater discharge; stream sampling points with blue infilling are those where only hydrochemical and discharge data were measured, while the ones with yellow infilling, are those with macroinvertebrate assemblages. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

even to total drying of the river channel, with increasing effects for the biota (e.g. Pires et al., 1999; Rincón and Cressa, 2000; Boulton, 2003; Magoulick and Kobza, 2003; Hakala and Hartman, 2004; Davey and Kelly, 2007; Benejam et al., 2010; Boix et al., 2010; Tornés and Ruhí, 2013; Stubbington et al., 2018).

Streams and rivers in the Mediterranean basin that were compatible with agricultural activity for thousands of years are now clearly negatively affected by current intensive agriculture and other human activities, such as industry, channelization, construction of dams or settlement growth (Hooke, 2006; Terrado et al., 2014). Water quality was