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Subsurface crustacean communities as proxy for groundwater-surface water interactions in the Henares and Tajuña Rivers floodplains, central Spain

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In the last decades, the linkage between surface water – groundwater via the hyporheic zone and the alluvial floodplains become more and more acknowledged. Hydrological exchanges between the stream and hyporheic zone ensure the transport of matter and energy and provide support for biogeochemical processes occurring in-stream bed sediments. Furthermore, the hyporheic zone is directly linked to permeable alluvial aquifers of which exchanges in both directions ensure the withstanding of a mixt biotic community's that may originate either from the surface benthic habitats or from the shallow aquifer.

Data on the subsurface crustacean assemblages are used to infer the surface-groundwater interaction in two-groundwater fed-streams in central Spain. The survey was conducted on 20 hyporheic sites (20-40 cm depth) and 28 shallow or deep boreholes. Multivariate statistics were applied to test for differences in crustacean communities resulting from changes in water chemistry between the upstream and downstream parts of the alluvial aquifer, and between the hyporheic zone and the alluvial aquifer. Our aims were to: 1) test whether groundwater discharges in-stream bed sediments are reflected in changes in the crustacean assemblage's structure; and 2) establish whether the surface water influence decreases with increasing groundwater depth and distance from the river. We further aimed to test whether the diversity-stability ecotonal paradigm associated with the distinct level of disturbances and stability at the interface surface-groundwater and the aquifer is reflected in groundwater crustacean community structure. We start from the assumption that groundwater ecosystems undergo significant changes in space and time, and that classical groundwater stability hypothesis ought to be changed to concepts operative for surface ecosystems: disturbance and resilience.

The streams are characterised by distinct gradients of surface-groundwater exchanges at spatial scale, with major interactions at the rivers headwaters compare to the lower part of the alluvial aquifer. The origin of the water in-stream bed sediments is indicated by water chemistry, whereas crustacean communities indicate surface-groundwater exchanges by modifications of the community's structure i.e. upwelling groundwater is indicated by large stygobites populations (obligate groundwater species), whereas downwelling surface waters is usually linked to mixed stygophiles and stygoxene populations. The downwelled surface water flow pattern has detectable influence on increasing nutrient content in shallow hyporheic waters and consequently, crustacean assemblages show distinctly high density and diversity. The crustacean diversity slightly declines with increasing depth, whereas no relationship with the population density was detected.

The results obtained highlight the recognition of crustacean communities as alternative proxy to investigate surface water-groundwater exchanges. We concluded that the hydrological connections between surface water and groundwater had a major influence in shaping the crustacean communities structure by controlling the diversity, density and ecological configuration of these populations. In the perspective of increasing alteration of surface-groundwater exchanges due to human actions, both small and large scale monitoring surveys are critical for placing groundwater changes in quality and quantity into a wider context, in order to enhance the assessment of subsurface ecosystems sensitivity to anthropogenic forcing and consequently reduce the negative impact.