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Distribution of biogeochemical compounds in interstitial and surface standing water bodies in the gravel bar of the Kizu River, Japan

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With 5 figures and 3 tables

Abstract: Distributions of biogeochemical constituents in interstitial water and isolated standing water bodies (or pools) were investigated in gravel bars 1 km in length to assess the ability of these waters to serve as a sink or source for nutrients. The temperature and concentration of major ions in interstitial water differed very little from those of river water. DO concentrations in interstitial waters were 5.7 ± 2.2 mg O_2/l and 3.5 ± 1.8 mg O_2/l at the side and dried-up channels, respectively. Concentrations of ammonium and nitrite of both interstitial waters at the side (0.50 ± 0.17 µM and 0.13 ± 0.09 µM, NH_4^+ and NO_2^-) and dried-up channels (0.90 ± 2.14 µM and 0.27 ± 0.37 µM) were lower than those of river water (1.7 ± 0.8 µM and 0.73 ± 0.22 µM), whereas nitrate (85 ± 25 µM at the side channel and 79 ± 36 µM at the dried-up channel) did not differ on average from those of river water (70 ± 12 µM), though they were often very low (< 10 % of those of river water) at shallow depths of the vegetated areas in the dried-up channel. Soluble reactive phosphorus (SRP) concentrations in interstitial waters at the dried-up channel (0.84 ± 0.53 µM) were lower than those at the side channel (1.9 ± 0.5 µM) and those of river water (1.5 ± 0.5 µM), and decreased downstream. These results suggest that this aerobic hyporheic zone can serve as a sink for ammonium, nitrite and SRP and to a lesser extent of nitrate. Concentrations of these nutrients in pool water varied greatly but did not differ on average from those of river water. Dissolved inorganic nitrogen (DIN) and SRP concentrations were negatively related to the algal biomass. Pool waters also had lower DIN concentrations at the vegetated areas and higher SPR concentrations at the bar head. These results suggest that nutrient

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concentrations in pool waters are controlled in a complex manner by algal assimilation and surface-subsurface water exchange. Therefore some pools may serve as a sink and others as a source for nutrients.

Key word: hyporheic zone, gravel bar, isolated pool, nitrogen, phosphorus.

Introduction

Streams and rivers receive nutrients from catchments, including anthropogenic sources such as agricultural fertilizer and wastewater, and transport them downstream. Increased loading of nutrients into streams and lakes has become one of the major environmental problems today. Nutrients imported into streams are altered in both the amount and form by biotic and abiotic processes as they pass through the stream (NEWBOLD 1996). Recently, it has been recognized that a subsurface hyporheic zone beneath the streambed and into the stream banks as well as the surface stream can make an important contribution to nutrient transformation, retention and export (e. g. TRISKA et al. 1989, VALETT et al. 1996, MULHOLLAND et al. 1997). The interaction between advected surface water and groundwater in a hyporheic zone controls nutrient transport into the stream from upland and riparian zones (e. g. TRISKA et al. 1993, SHEIBLEY et al. 2003). Vertical (along riffle and pool sequences) and longitudinal (through gravel bars) hydrological exchanges between surface and subsurface zones also influence the nutrient distribution in surface streams (e. g. VALETT et al. 1994, DENT et al. 2001, MALARD et al. 2002). WHITE (1993) represented that the dominance of ground water input in hyporheic zones decreases whereas that of advected channel water increases from headwater reaches to downstream sections. This conceptual model suggested that biogeochemical processes in hyporheic zones and their contribution to surface water qualities change with sediment accumulation.

In streams and rivers with a hyporheic zone dominated by advected channel water, stream water moves from the surface to the subsurface zone and inversely, and as a result its chemistry is affected in each zone. These processes are important mechanisms in the development of stream water chemistry. Biogeochemical changes in channel waters penetrating stream beds and gravel bars or the so-called parafluvial zones described by BOULTON et al. (1992) have been reported (e. g. VALETT et al. 1990, HOLMES et al. 1994, FINDLAY et al. 1993, HENDRICKS & WHITE 1995, CLEVEN & MEYER 2003). Many of these studies were carried out on the hyporheic zone to a depth of less than a few meters over bed rock or along a subsurface flow shorter than a few dozen meters in gravel bars. Only a few reports have described the hyporheic biogeochemistry in rivers with well developed alluvia where larger gravel bars on a scale of over hundreds of meters have developed (VERVIER et al. 1993,