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Nutrient limitations to aquatic production along an alluvial groundwater connectivity gradient in semi-arid northwest Australia

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Primary production of intermittent streams in hot arid regions, such as the geologically ancient Pilbara region of northwest Australia, is strongly limited by both water and nutrient availability. Pulses of allochthonous materials can be significant source of nutrients and carbon during short periods of connected flow. However, during interflow periods, which may last months to years, surface water retracts to a series of surface disconnected pools, where hydrological processes including hyporheic exchange and evapo-concentration of ions are of increasing importance in maintaining bioavailable nutrients for primary production.

In the Pilbara, the persistence of individual pools during interflow periods is strongly linked to local topography and connectivity to alluvial groundwater. We might thus expect that autochthonous production is greater in pools that become disconnected from groundwater due to increased concentration of nutrients. We thus investigated the importance of nitrogen (N) and phosphorus (P) limitations on aquatic production along an alluvial groundwater connectivity gradient. First, we used *in-situ* bottle incubations and a ^{13}C-enriched $NaHCO_3$ isotopic tracer to measure rates of charophyte and phytoplankton production in response to nutrient amendments. Second, we paired a nutrient diffusing substrata limitation experiment with high performance liquid chromatography to i) identify which nutrient(s) limit periphyton production, and ii) how the periphyton community structure changes within pools along the alluvial gradient.

Charophyte production was 2 mg C g^{-1} DW h^{-1} while phytoplankton production was orders of magnitude less ($\sim$0.01 mg C g^{-1} DW h^{-1}). Although charophytes showed no clear respiration response to short-term nutrient addition, productivity was positively correlated to both charophyte N and P content (R^2 = 0.65, $p < 0.001$ and R^2 = 0.41, $p < 0.001$ respectively). This relationship was stronger in pools which were disconnected from alluvial groundwater (N: R^2 = 0.92, $p < 0.001$ and P: R^2 = 0.77, $p < 0.001$). Short-term phytoplankton production was N limited in some pools ($F > 7.6$, $p < 0.009$) but this was not directly linked to alluvial connectivity. The chemotaxonomic response of periphyton algae to experimental increases of biologically available N and P showed clear shifts in production and community composition, with nitrogen additions aiding in production, whilst P additions alone did not increase production and in some instances inhibited growth of some taxa. Unique photosynthetic pigment peaks were identified in each sample and matched with published values. Clearly both N and P, along with alluvial groundwater connectivity, have significant and complex roles in regulating production in these pools. Altered hydrology due to changing climate or water abstraction may thus have significant but as yet poorly understood impacts on the ecological functioning of intermittent streams.