The ecological effect of acid conditions and precipitation of hydrous metal oxides in a Rocky Mountain stream

Diane M. McKnight & Gerald L. Feder

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Abstract

Periphyton and benthic invertebrate assemblages were studied at the confluence of two Rocky Mountain streams, Deer Creek and the Snake River near Montezuma, Colorado. Upstream from the confluence the Snake River is acidic and enriched in dissolved trace metals, while Deer Creek is a typical Rocky Mountain stream. In the Snake River, downstream from the confluence, the pH increases and hydrous metal oxides precipitate and cover the streambed. The algal and benthic invertebrate communities in the upstream reaches of the Snake River and in Deer Creek were very different. A liverwort, Scapania undulata var. undulata, was abundant in the Snake River, and although periphyton were very sparse, there were as many benthic invertebrates as in Deer Creek. Downstream from the confluence, the precipitation of hydrous metal oxides greatly decreased the abundance of periphyton and benthic invertebrates. This study shows that in streams metal precipitates covering the streambed may have a more deleterious effect on stream communities than high metal-ion activities.

Introduction

Growth of periphytic algae and benthic invertebrates in streams can be affected by the nature of the surface available for growth and by the chemistry of the overlying aquatic medium. In streams receiving acid mine drainage or otherwise metal-stressed, two factors responsible for decreases in the abundance and diversity of periphyton communities are: (1) Toxicity resulting from acid conditions and high concentrations of dissolved trace metals; and (2) destabilization of the substrate by flocculent metal precipitates (Parsons, 1968; Warner, 1971; Lampkin & Sommerfield, 1982). Similarly, low pH and deposition of iron hydroxide have been shown to limit the abundance and species of benthic invertebrates (Hynes, 1970). Our purpose in this study was to determine which of these two factors had a more adverse effect in the Snake River, a small Rocky Mountain stream.

Study area

The confluence of the Snake River and Deer Creek in the Rocky Mountains, near Montezuma, Colorado, is at an elevation of about 3230 m above sea level. These streams are very steep and rocky and were first studied by Theobald et al. (1963). The watersheds of both streams are underlain by Precambrian igneous and metamorphic rocks that have been intruded by granitic rocks of Tertiary age (Theobald et al., 1963). Mineralized veins containing iron, zinc, lead and silver sulfides are found scattered throughout the watersheds. There are many old mine workings, but currently there has been little mining activity (Moran & Wentz, 1974). The four sites sampled in this study are shown in Fig. 1. As indicated in the hydrograph for water years 1980 and 1981 at a Snake River site 10 km downstream from site 4 (Fig. 2), in the winter the streams are covered by snow (1 to 2 m deep) under-
lain by about 0.5 m of ice. In June and July, melting of the snow pack results in large increases in stream discharge. Open water, low flow conditions occur from August through mid-October and at that time the streamflow at sites 1 and 2 is between 0.06 and 0.28 m$^3$s$^{-1}$. The peak discharge in the Snake River during June and July of 1981 was much less than usual because of the low snowfall during the previous winter.

The water chemistry at sites 1–4 on August 18, 1980 is shown in Table 1. These values are representative of low flow during the late summer and autumn. Upstream from the confluence with Deer Creek, the Snake River has a low pH (3.5–4.3) and high concentrations of filtrable trace metals ($\text{Al} = 4.0$ mg l$^{-1}$ and $\text{Fe} = 0.7$ mg l$^{-1}$). The low pH and high Fe concentration result from the weathering of pyrite disseminated in the rocks of the watershed; the high Al concentration is a result of solution of aluminous minerals by the acidic waters. Chemical equilibrium calculations using MINEQL, a compu-