Diurnal and seasonal cycles of dissolved inorganic carbon and dissolved metals at Lambert Run, Harrison County, WV

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Extended Abstract

Diurnal cycling of dissolved metals has been observed in waters affected by coal mine drainage (CMD), (Riddell, 2015; Vesper et al. 2010) and metal mine drainage (Gammons et al. 2010; Nimick et al. 2005; Sullivan et al. 1998). Cycling of inorganic carbon (CO_2) has also been observed in karst rivers (Kurz et al. 2013), concurrently with dissolved metals in mountain headwater streams (Poulson et al. 2010) and in a metal mine affected river (Parker et al. 2010). Fewer studies have examined the diurnal cycles of metals in CMD systems containing high CO_2. The biological and geochemical effects on metal cycling in CMD during the daily solar cycle and seasonal temperature cycles have implications for water quality monitoring and evaluating the effects of CMD remediation techniques.

This study reports diurnal concentrations of dissolved metals and dissolved inorganic carbon (DIC) at two locations across three seasons (winter, spring, and summer) in a CMD passive treatment system. The first location was 50 m from the mine portal outflow in a channel lined with limestone riprap, and the second location was 138 m from the outflow in an altered natural wetland. DIC, dissolved oxygen (DO), pH, temperature, total Fe, and reduced Fe were measured in the field. Water samples were collected for laboratory analysis of dissolved metals and $\delta^{13}C_{DIC}$. Data were analyzed by fitting the measured concentrations to a cosine curve to confirm statistically significant ($p \leq 0.01$) diurnal behavior. The linear distance from the mine portal to the end of the natural wetland is approximately 172 m, but the length of the discharge stream is longer due to the meandering flow path through the wetland.

A spatial analysis of the 172 m from the portal outflow to the end of the wetland was conducted in the spring and summer to characterize the change in chemical parameters throughout the treatment area. In both seasons, pH showed a measurable increase downstream while CO2, DIC, and acidity decreased in both seasons. During the diurnal study, the upstream location exhibited significant diurnal cycles of pH, temperature, DO, and Al in all seasons; K exhibited significant diurnal behavior in winter; Zn had significant diurnal behavior only in the spring; and total and reduced Fe had significant diurnal behavior only in summer. At the downstream location, pH, temperature, DO, and Ni exhibited significant diurnal behavior in all seasons; As exhibited significant diurnal behavior only in winter; Y exhibited significant diurnal behavior only in spring; and $\delta^{13}C_{DIC}$, Mn, and total Fe exhibited significant diurnal behavior in both spring and summer. At the upstream location, average concentrations of Fe, Al, Y, Zn, and K increased from winter to summer while CO_2 and DIC remained relatively constant. At the downstream location, concentrations of the dissolved metals remained relatively constant across seasons and were lower than concentrations at the upstream location.

The decrease in concentration magnitude between the upstream and downstream locations demonstrates the effectiveness of the CMD treatment techniques at this site. These results also support the importance of robust spatial, seasonal, and daily monitoring of treated mine drainage systems to quantify the total metal concentrations

of the discharge stream. Changing seasonal and daily temperatures, as well as biological productivity, drive the diurnal behavior of DIC and dissolved metals in these systems.

Keywords: Coal mine drainage, diurnal, metals, CO_2, DIC

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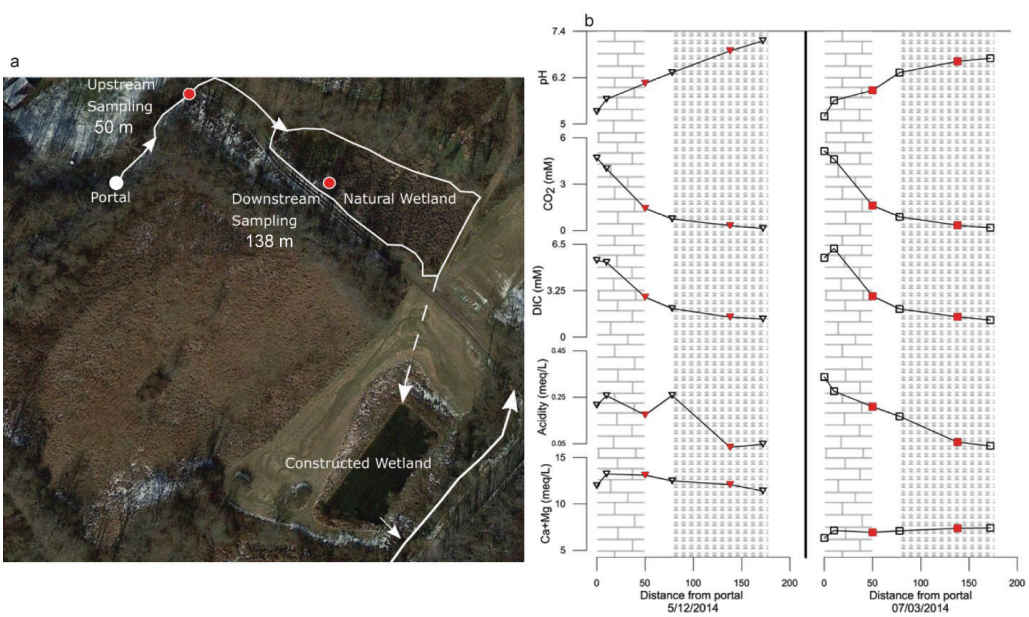

Figure 1 *Aerial view and schematic of the treatment area. Locations sampled during the diurnal study are indicated in red (a). Results of the spatial study that sampled 6 locations from the portal to the end of the natural wetland; diurnal study locations are again indicated in red.*

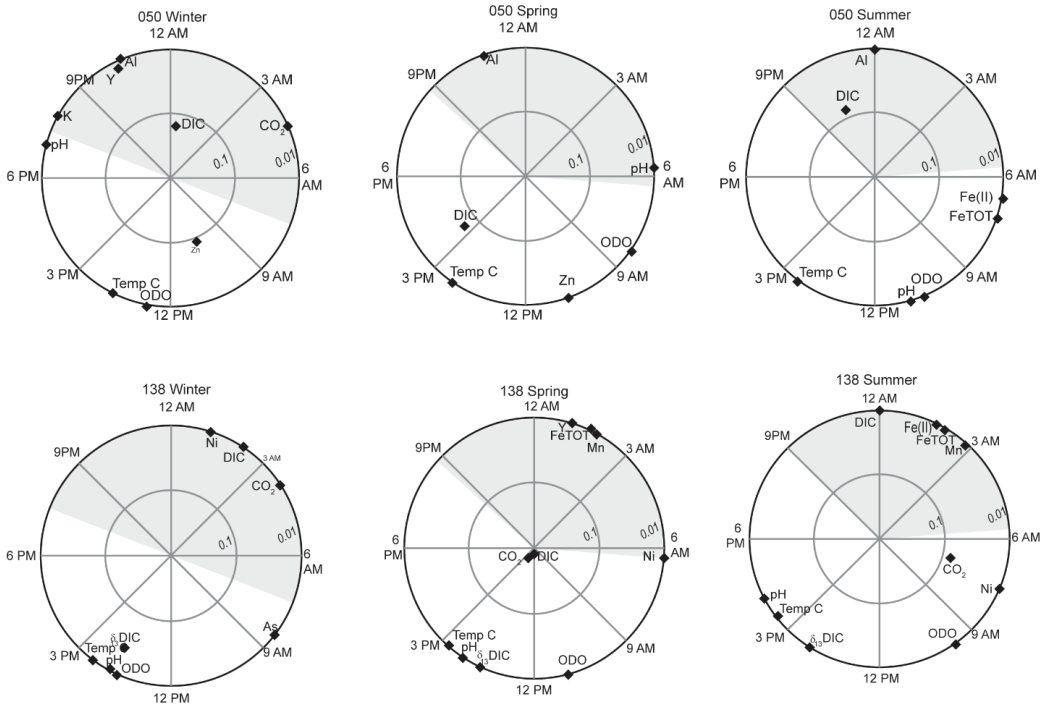

Figure 2 *Polar plots showing parameters with statistically significant diurnal behavior according to the f-test applied to the cosine curve fitting. The circle represents a 24-h period where 45° = 3 h. The inner circle represents a statistical significance of α = 0.01 and the outer circle represents a statistical significance of α = 0.01. Locations of parameters around the circle indicate time of peak concentration with the shaded area representing hours of darkness.*