Estimating carbon dioxide flux from coal mining discharge portals in the bituminous coal field region of Pennsylvania

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Extended Abstract

The interaction of water and oxygen with the geologic strata of coal mined sites leads to the creation of coal mine drainage (CMD). One often overlooked consequence of CMD is the enhanced release of geologically-bound inorganic carbon. The interaction of CMD with carbonate rocks drives their dissolution, leading to the release of dissolved inorganic carbon (DIC) as either carbon dioxide (CO_2) or as bicarbonate (HCO_3^-). Estimating the extent of DIC release is crucial to understanding the importance of this process to carbon cycling in coal-mining affected areas.

This study examined 25 CMD points in an approximately 2,370 km² area within the Pennsylvania (PA) bituminous coal field region (Fig. 1), specifically in Fayette, Washington, Westmoreland, and Allegheny Counties. Sample points included discharge pipes, mine portals, and seeps within the Monongahela River watershed. Discharge, DIC, CO_2, pH, and geospatial factors were measured along with major ions to estimate the carbon flux of this region. Additionally, one sample point was monitored monthly to capture seasonal variability. The DIC and CO_2 concentrations were measured using a CarboQC with a method modified from Vesper and Edenborn (2012) and Vesper et al. (2015).

Concentrations of CO_2 in CMD ranged from approximately 15 to 310 times greater than the current atmospheric equilibrium concentration (based on 420 ppm of CO_2 in the atmosphere (National Oceanic and Atmospheric Administration (NOAA) 2023)). The average CO_2 flux was approximately 23 t-CO_2/a. The total CO_2 flux for the 25 sites in the study area is approximately 570 t-CO_2/a. This rate can be scaled to the bituminous coal field region of PA by taking the total CO_2 flux from the study area in t-CO_2/a and dividing it by the fraction of the study area contained within the bituminous coal field region of PA. After scaling this rate, the CO_2 flux is estimated to be about 14,340 t-CO_2/a from the bituminous coal field region of PA. This is approximately 6% of the emissions from the smallest coal-fired power plant in PA in 2022 (United States Environmental Protection Agency (U.S. EPA), 2023). The dataset does not include CMD areas within the study area where no point source was found, such as CMD swamp areas and outcrop seeps, and it does not include points that were inaccessible due to various reasons, such as private property restrictions and physical inaccessibility. It is estimated that around 35 additional CMD locations exist within the study area that were not able to be sampled due to these reasons. Therefore, the results of this study are likely to underestimate the total CO_2 flux. Additionally, it should be recognized that the dataset does not address temporal or seasonal variability in the flux estimates.

This study measures CO_2 fluxes from CMD in the bituminous coal field region of PA, enhancing our understanding of coal mining's environmental impact. By quantifying cumulative CO_2 flux from the sample points, this research captures the variability in discharge points typical in bituminous coal mining regions. Overall, this study contributes to a better understanding of the environmental impact of coal mining operations, the importance of CMD in the regional carbon budget, and the application of accurate CO_2 degassing estimates.

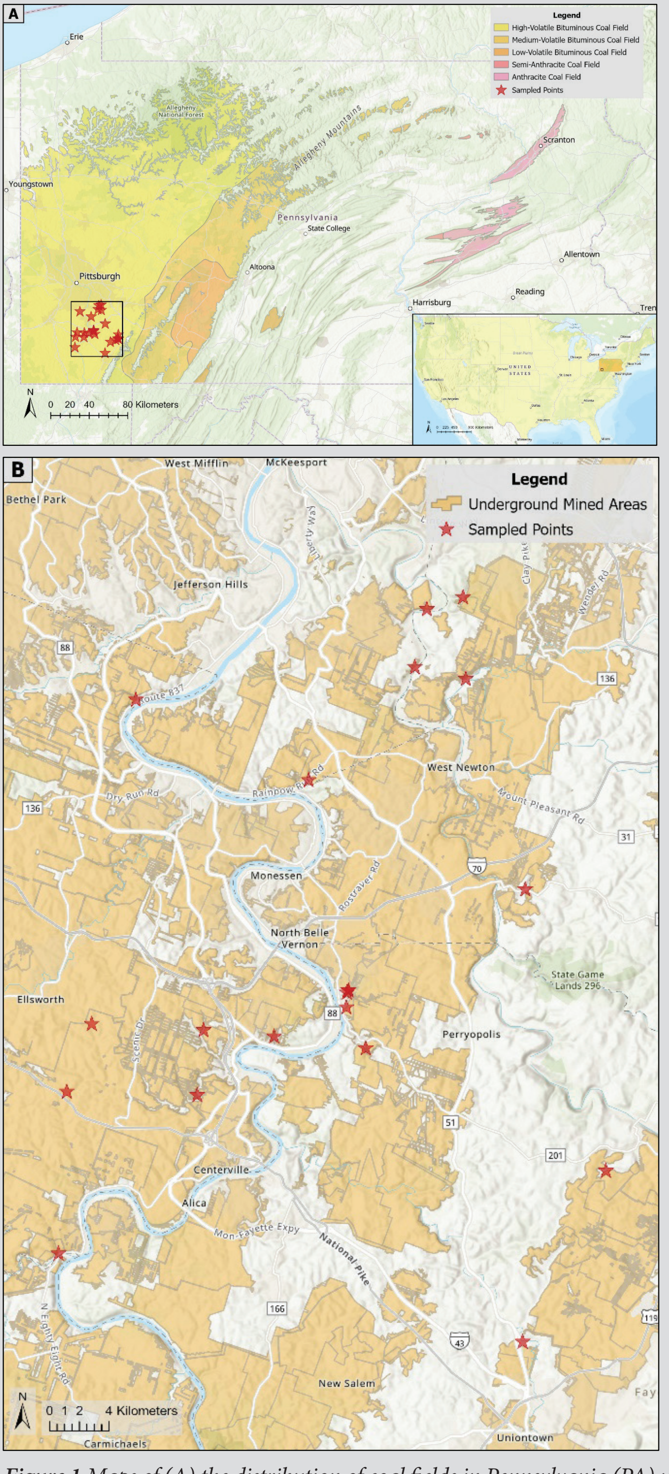

Figure 1 *Maps of (A) the distribution of coal fields in Pennsylvania (PA) with the study area extent and (B) the sampled points with digitized maps of underground coal mines (PA Department of Conservation and Natural Resources (DCNR), 2021; PA Department of Environmental Protection (DEP), 2023).*

Keywords: CO_2, degassing, coal mine drainage, carbon cycling

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