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The influence of environmental factors on the carbon dioxide flux across the water–air interface of reservoirs in south-eastern Poland

Renata Gruca-Rokosz*, Lilianna Bartoszek, Piotr Koszelnik

Faculty of Civil and Environmental Engineering and Architecture, Rzeszów University of Technology, Rzeszów, Poland

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ABSTRACT

Studies concerning the emission of carbon dioxide (CO₂) were carried out in 2009–2012 for six reservoirs located in four provinces of south-eastern Poland. The CO₂ flux across the water–air interface was measured using the “static chamber” method. The measured fluxes of CO₂ (FCO₂) ranged from –30.64 to 183.78 mmol/m²/day, and the average values varied in the range from –3.52 to 82.11 mmol/m²/day. In most of the cases, emission of CO₂ to the atmosphere was observed. The obtained values of CO₂ fluxes were comparable to values typical for other temperate reservoirs. Analysis of the influence of selected environmental factors on the FCO₂ showed that it depends on parameters characterizing both the sediments and surface water. The CO₂ flux at the water–air interface was positively correlated with parameters of bottom sediments such as porosity, content of organic carbon and total nitrogen; and negatively with pH value and δ¹³C of organic carbon. In the case of the parameters characterizing surface water, positive dependences on the concentrations of nitrate and total nitrogen, and negative relationships with water temperature and chlorophyll *a* concentrations, were found.

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Introduction

Carbon dioxide (CO₂) is the most important anthropogenic greenhouse gas, whose concentration in the atmosphere is growing systematically, causing an increase in average air temperature. The global concentration of CO₂ in the atmosphere has increased from the pre-industrial value of about 280 ppm to 379 ppm in 2005. If these trends continue, they could have a negative influence on the environment and socio-economic factors (IPCC, 2007).

Therefore, studies concerning the emission of this gas from various anthropogenic sources are being carried out worldwide. One of these sources is reservoirs located in different climatic zones. During reservoir damming, a certain

area of land, which is covered with vegetation, is flooded. Furthermore, in an existing reservoir, organic matter is produced in the process of primary production and delivered from the catchment. The thus accumulated organic material dies and is deposited in the bottom sediments, where it is decomposed by bacteria. In the presence of oxidants, the organic matter is mineralized, and the final product of this process is, among others, CO₂. Under anaerobic conditions, the organic matter is degraded by fermentation, and CO₂ and CH₄ are the gaseous end products of this process. The amount of CO₂ transported into the atmosphere via the water–air interface is not equivalent to the amount produced in the sediment, and depends on many factors. For example, methanogenesis (reduction of CO₂) and photosynthesis

* Corresponding author. E-mail: renatagr@prz.edu.pl (Renata Gruca-Rokosz).

processes are sinks for CO₂. Furthermore, CO₂ can be produced in the water column during mineralization of organic matter as well as absorbed from the atmosphere.

The main aim of the research was obtaining information on the CO₂ flux at the water – air interface from selected reservoirs and analysis of the factors controlling this flux.

1. Material and methods

1.1. Study area

The research was conducted between 2009 and 2011, from spring to autumn. Six reservoirs located in four provinces of south-eastern Poland were selected for the study: (reservoirs in Podkarpackie Province: Rzeszów — 50° 2' 1" N, 22° 0' 17" E, Maziarnia — 50° 21' 0" N, 21° 55' 59" E and Besko — 49° 33' 10" N, 21° 55' 56" E; reservoir in Lubelskie province: Nielisz — 50° 48' 1" N, 23° 2' 38" E; reservoir in Świętokrzyskie province: Chańcza — 50° 40' 25" N, 21° 2' 48" E; reservoir in Małopolskie province: Klimkówka — 49° 33' 8" N, 21° 5' 16" E) (Fig. 1). The reservoirs selected differed in size, age, degradation level, and also the influence of anthropogenic pollution. In Table 1 characteristic parameters of the studied reservoirs are shown.

In each reservoir, the studies were conducted at two stations (Fig. 1) located in the shallow parts of the reservoir. Their depth, depending on the water level, ranged from 0.5 to 1.0 m. The stations R1, M1, B1, N1, C1 and K1 were located in the shallow parts of the inflow area, and the stations R2, M2, B2, N2, K2 and C2 in the upper parts of the reservoirs.

1.2. Measurement of carbon dioxide flux at the water–air interface

The CO₂ fluxes were estimated using a “static chamber” method. A stainless-steel chamber (0.3 m × 0.3 m × 0.16 m) equipped with a dry battery driven fan and a small vent stopped by a silicone septum for sampling was used. Five gas samples from the chamber air headspace were manually withdrawn into gastight syringes at 0, 10, 20, 30, and 40 min after deployment. All samples were transported to the laboratory, and the gas concentration was analyzed within 4 hr. The samples were analyzed using a Pye Unicam gas chromatograph (GC, model PU-4410/19) equipped with a flame ionization detector (FID) and a stainless steel column packed with Haye Sep. Q, 80/100 Mesh, 6 ft. in length and 2 mm ID. The GC was also equipped with a methanizer to detect low levels of CO₂. The methanizer is packed with a nickel catalyst

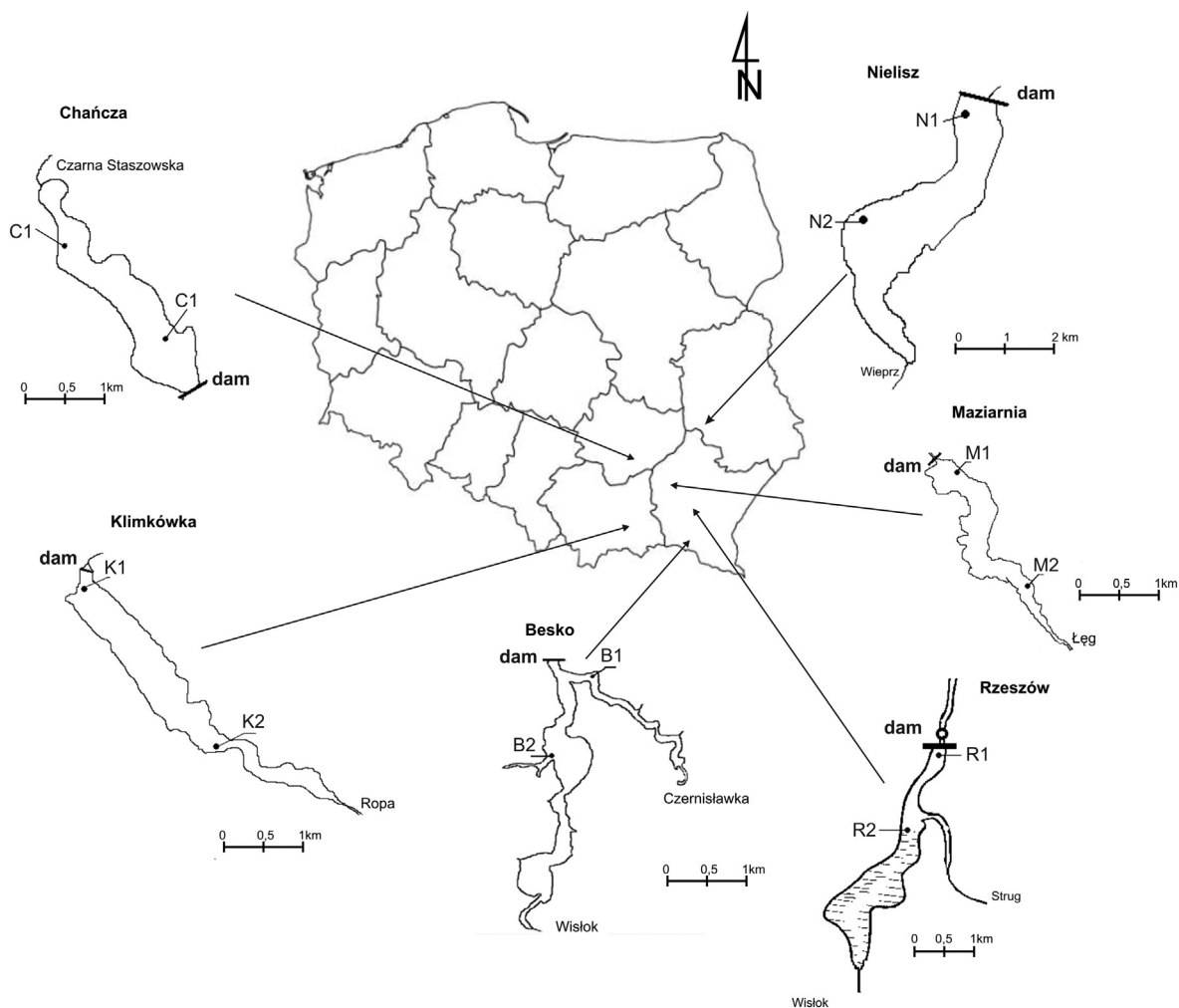


Fig. 1 – Localization of the studied reservoirs with sampling stations.

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