Unraveling the Drivers of Bubble Methane Emissions in Urban Rivers: The Roles of Organic Carbon, Temperature, and Water Depth

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Bubble methane (CH_4) emissions are recognized as a significant contributor to elevated CH_4 fluxes in urban rivers. However, due to the general lack of simultaneous monitoring of isotopes and bubble fluxes, our understanding of the driving factors and pathways of bubble CH_4 emissions in urban rivers remains limited. This study utilized in-situ surveys of the Huangpu River Basin in Shanghai, a typical megacity in China, to investigate the spatial and temporal variations of bubble CH_4 emissions and its potential controlling factors. In addition, we investigated the bubble CH_4 production processes through the combination of laboratory incubation and isotope techniques. In this study, bubble CH_4 fluxes ranged from 4.49 to 591.42 mmol m^{-2} d^{-1} (median: 39.36 mmol m^{-2} d^{-1}), contributed nearly 80% of CH_4 emissions and varied on spatial scales. High bubble CH_4 fluxes were attributed to elevated organic carbon content in sediments and the shallow water depths of urban rivers. Additionally, CH_4 emissions from bubbling exhibited a high temperature sensitivity, which was modulated by the ecosystem trophic status. Furthermore, our results demonstrated that the bubble emission rate was correlated with the variability of $\delta^{13}C$-CH_4, with the $\delta^{13}C$-CH_4 in bubbles ranged from -68.09‰ to -48.23‰. The relatively high bubble emissions were maintained by the acetoclastic methanogenesis process, which may be related to the input of fresh organic matter. Overall, further detailed isotopic and microbial investigations are necessary to constrain the contributions of different pathways to CH_4 production, consumption, and emissions.