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Quantitative Polymerase Chain Reaction Analysis of Phytoplankton Composition and Abundance to Assess Eutrophication: A Multi-Year Study in Twelve Large Rivers across the United States

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Abstract : Phytoplankton plays an essential role in freshwater aquatic ecosystems and is the primary group synthesizing organic carbon and providing food sources or energy to ecosystems. Therefore, the identification and quantification of phytoplankton are important for estimating and assessing ecosystem productivity (carbon fixation), water quality, and eutrophication. Microscopy is the current gold standard for identifying and quantifying phytoplankton composition and abundance. However, microscopic analysis of phytoplankton is time-consuming, has a low sample throughput, and requires deep knowledge and rich experience in microbial morphology to implement. To improve this situation, quantitative polymerase chain reaction (qPCR) was considered for phytoplankton identification and quantification. Using qPCR to assess phytoplankton composition and abundance, however, has not been comprehensively evaluated. This study focused on: 1) conducting a comprehensive performance comparison of qPCR and microscopy techniques in identifying and quantifying phytoplankton and 2) examining the use of qPCR as a tool for assessing eutrophication. Twelve large rivers located throughout the United States were evaluated using data collected from 2017 to 2019 to understand the relation between qPCR-based phytoplankton abundance and eutrophication. This study revealed that temporal variation of phytoplankton abundance in the twelve rivers was limited within years (from late spring to late fall) and among different years (2017, 2018, and 2019). Midcontinent rivers had moderately greater phytoplankton abundance than eastern and western rivers, presumably because midcontinent rivers were more eutrophic. The study also showed that qPCR- and microscope-determined phytoplankton abundance had a significant positive linear correlation (adjusted R^2 0.772, p-value < 0.001). In addition, phytoplankton abundance assessed via qPCR showed promise as an indicator of the eutrophication status of those rivers, with oligotrophic rivers having low phytoplankton abundance and eutrophic rivers having (relatively) high phytoplankton abundance. This study demonstrated that qPCR could serve as an alternative tool to traditional microscopy for phytoplankton quantification and eutrophication assessment in freshwater rivers.

Keywords : phytoplankton, eutrophication, river, qPCR, microscopy, spatiotemporal variation
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