Lessons learned about the effect of reduced anthropogenic activities on water quality in a large lake system and opportunities towards sustainable management

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Abstract

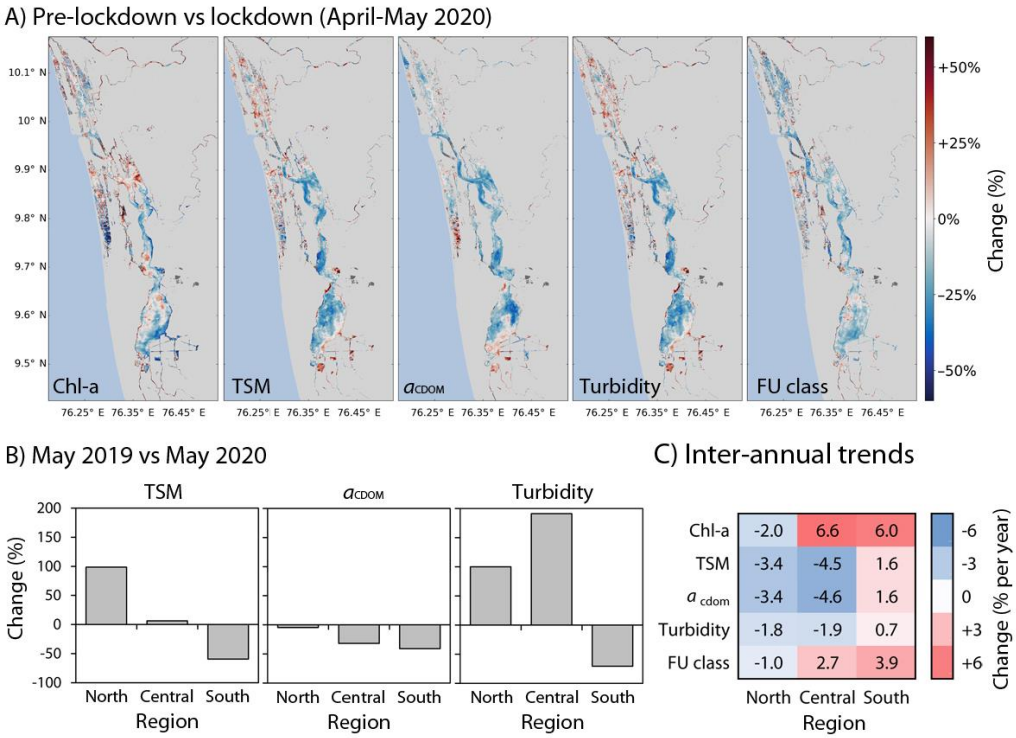
Despite considerable efforts to protect vulnerable marine, coastal, and freshwater ecosystems, anthropogenic activities remain one of the main causes of poor water quality in rivers, lakes and wetland systems worldwide [1]. To move towards the sustainable management of coastal and aquatic ecosystems, it is important to understand how both natural and anthropogenic processes affect water quality. In 2020, a unique opportunity arose to study water quality in a large lake system in the southwest of India during a period when anthropogenic pressures were reduced due to a nationwide lockdown in response to the COVID-19 pandemic. Using remote sensing and *in situ* observations to analyse changes in five different water quality indicators, we showed that water quality improved in large areas of Lake Vembanad during the lockdown in 2020 [2]. The lessons learned illustrate that a coordinated response in reducing anthropogenic activities, as seen during the lockdown, could help achieve the targets set out in United Nation's Sustainable Development Goals 3, 6 and 14 and significantly reduce aquatic pollution and improve water quality by 2030.

Outline of empirical facts and issues

Lake Vembanad is considered one of the most polluted estuaries in India and water quality has degraded over the past decades with the continued observation of high levels of suspended and dissolved matter, turbidity and nutrients, and the persistence of pathogenic bacteria [3,4]. The region has experienced high levels of anthropogenic pressures leading to adverse ecological and socioeconomic impacts with consequences for achieving the targets set out in the United Nation's Sustainable Development Goals related to the conservation and sustainable management of aquatic ecosystems (SDG-14), water quality (SDG-6) and health (SDG-3). During 2020, a unique opportunity arose to study water quality in Lake Vembanad under reduced anthropogenic activities. In response to the global pandemic caused by SARS-CoV-2, the government of India imposed a nationwide lockdown and people were required to stay at home while most services were suspended with the exemption of essential services. To study whether the reduction in anthropogenic activities during the nationwide lockdown led to improved water quality in Lake Vembanad, we used remote sensing and *in situ* observations to analyse changes in five different water quality indicators [2]. Trends between the month preceding lockdown (28 February–24 March 2020) and the first month of lockdown (25 March–24 April 2020) were analysed as well as long-term trends in water quality, as observed in the satellite record (2013–2020).

Our findings showed that water quality improved in large areas of Lake Vembanad during April 2020 as evidenced by a decrease in suspended and dissolved matter, and turbidity, all leading to clearer waters (Figure 1A) [2]. The observed changes in water quality indicators were strongest in the central and southern regions of Lake Vembanad. *In situ* observations supported the remotely observed changes in water quality in the southern regions of Lake Vembanad later in the lockdown during May 2020 (Figure 1B) [2]. A decrease in suspended and dissolved matter, and turbidity was not observed during the same period in preceding years, suggesting that the reduction in anthropogenic activities associated with the nationwide lockdown in 2020 had a positive effect on the water quality in Lake Vembanad. Further analysis of longer-term trends (2013–2020) showed that water quality has been improving over time in the more northern regions of Lake Vembanad independent of the lockdown.

Figure 1. Results of the water quality study in Lake Vembanad, Kerala, India, during lockdown. Five different water quality indicators were studied, including chlorophyll-a [Chl-a], total suspended matter [TSM], absorption by dissolved organic matter [aCDOM], turbidity and the Forel-Ule [FU] classification of water colour. Panel A) shows the percentage change in the five water quality indicators between the month preceding and the first month of a nationwide lockdown in India (based on remote sensing observations). Panel B) showed the percentage change in three of the water quality indicators between May 2019 and May 2020 (right after lockdown) for three regions in the lake. Panel C) shows the inter-annual trends between 2013-2020 for the five water quality indicators for the same three regions.



High concentrations of suspended and dissolved matter in Lake Vembanad have been related to urban, agricultural, and industrial activities [3,4] and the restriction on these anthropogenic activities at specific locations during the lockdown in 2020 may explain why the observed improvement in water quality was strongest in the central and southern regions of Lake Vembanad. A halt to transport, industry, and hospitality services could also have had a positive effect on water quality in the entire region, while the confinement of people to their homes during lockdown may have led to increased domestic waste and sewage discharge in highly populated areas such as in the north of Lake Vembanad near Kochi. The hydrological features may have further played a part in determining the distribution of dissolved and suspended matter in Lake Vembanad during and after the lockdown in 2020. Rivers and tidal movement play key roles in the transportation of dissolved and suspended matter into the lake during the dry season (December–May), while rainfall and enhanced flushing rates can dilute the negative effects of anthropogenic activities on water quality during the wet season (June–November) [3]. Other processes, such as the atmospheric and wind-induced deposition of fine particles, may have further contributed to an improvement in water quality in Lake Vembanad, as lower levels of nitrogen dioxide and fine particulate matter were observed during lockdown [5].

Policy recommendations

Water quality can improve substantially when anthropogenic activities are reduced as shown in this study despite not being able to pinpoint specific sources of pollution. The lessons learned through this study provide important insights into the opportunities towards sustainable management of Lake Vembanad and other coastal and aquatic ecosystems, with recommendations including:

- A coordinated response in reducing anthropogenic activities, as seen during lockdown, can improve water quality. Importantly, continuing such a coordinated response could help achieve the targets set out in SDG-3, SDG-6 and SDG-14 and significantly reduce aquatic pollutions and improve water quality by 2030.

- Continued scientific research and the monitoring of water quality on short and longer time scales can aid in the knowledge-based decision making required for the sustainable management of aquatic systems. Whilst we did not observe a prolonged positive effect on water

quality after lockdown restrictions were lifted, water quality seems to be improving in some regions when considering inter-annual trends.

• Remote sensing observations can aid in the sustainable management of aquatic systems, with free and open data available at high temporal and spatial resolutions [6]. Bridging the gap between researchers and policy makers is essential in this, with information being provided on a regular and easily accessible basis to those who are responsible for the management of aquatic systems.

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