The colors of eutrophication

By Giulia Valerio

The color of the water can say a lot about the story of a lake. This short account presents the story of the picture on the cover of this issue, which frames the Natural Reserve of "Torbiere", a manmade shallow wetland made by a set of interconnected ponds, dating back to the beginning of the twentieth century, when the site was exploited for peat extraction. The low transparency and the algal blooms are the tip of the iceberg in a system where the last decades have seen a progressive loss in biodiversity. On the upper part of the picture, the southern tip of deep Lake Iseo is visible, an originally oligotrophic lake, now struggling with deep anoxia. This clashes with the relevance of the surrounding context and demands choices for the future identity of this place and consequent management actions.

Lake Iseo, Italy

Starting from the 70's, a decrease in nutrient loads to lakes was achieved mainly by improving wastewater treatment and reducing phosphorus in laundry detergents. However, in many cases such effort has not yet led to the desired improvement in water quality, likely because of the presence of unaccounted nutrient sources. Accordingly, further reducing eutrophication in this century must focus on limiting leaching from agricultural environments, runoff over urban areas and overflowing discharges by combined sewers. This task will be challenging because they are all discontinuous and hydrologically-driven inputs, more difficult to be measured and to be managed than wastewater point sources.

Within the research project ISEO (https://hydraulics.unibs.it/hydraulics/attivita-scientifica/iseo-project/), we set ourselves the goal of assessing the residual phosphorous inputs to Lake Iseo, a deep pre-alpine lake located in the northern Italy which underwent a severe worsening of its water quality during the second half of the twentieth century. The drainage network around this lake receives the input of combined sewer systems (CSS), draining relatively small tributary sub-catchments. During wet weather periods, the untreated mixture of stormwaters and sewage, exceeding either the sewers conveyance or the final waste water treatment plant (WWTP) processing capacity, is discharged into the lake as combined sewer overflows (CSOs) by means of spillways. Among them, the network of a local municipality delivers during rainy events an intermittent and untreated discharge directly to the Torbiere wetland (PR, Figure 1a). Even though its volumetric contribution is marginal, we hypothesized that the nutrient load was not[2].

With reference to the eastern Lake Iseo shoreline (Figure 1a), we provided a comprehensive evaluation of the overall efficiency of the CSS by combining the results of a monitoring campaign and of hydraulic modelling[1]. For this purpose, a hydraulic model of the sewer network was implemented and forced by the rainfall data available at 1/10 min^{-1} frequency. At CF and PAR sites (Fig. 1a), an extensive real-time monitoring campaign provided time series of the flow discharges and sewage samples during CSOs. Water depth and flow data allowed to calibrate the model during wet periods, providing the hydrological parameters of the corresponding watersheds, that were used for the lumped hydrological modelling of the other tributary sewer systems. During CSOs at the two reference sites, water samples were automatically collected to characterize the overflowing sewage during 8-hour long rain events. The 10 year-long simulation of the calibrated model allowed to quantify the volume of water discharged into the lake during wet weather periods, which resulted in $1{,}21\ 10^6\ m^3$/year, corresponding to a volumetric efficiency of CSS of 81%. In terms of loads, these volumes were seen to correspond to 3445 kg of total phosphorous and 21758 kg of total nitrogen per year. Considering that the western collector has similar characteristics to the eastern one, we could conclude that ~7000 kg of overall residual total phosphorus (TP) from the CSOs of the two peripheral sewers are delivered each year to the lake. This is in the order of 5% of the TP load from the overall watershed (about 130 tonns/year[3]), larger than that adopted during the initial design of the main sewer around the lake. It is worth noting that the concentrations of nutrients provided evidence of a moderate-weak first flush of the overflows from tributary networks, whose strength is significantly correlated with the duration of the antecedent dry-weather period. The occurrence of frequent CSO events with moderate volumes implies that storage tanks would be effective measures to reduce the impact of the overflows[1].

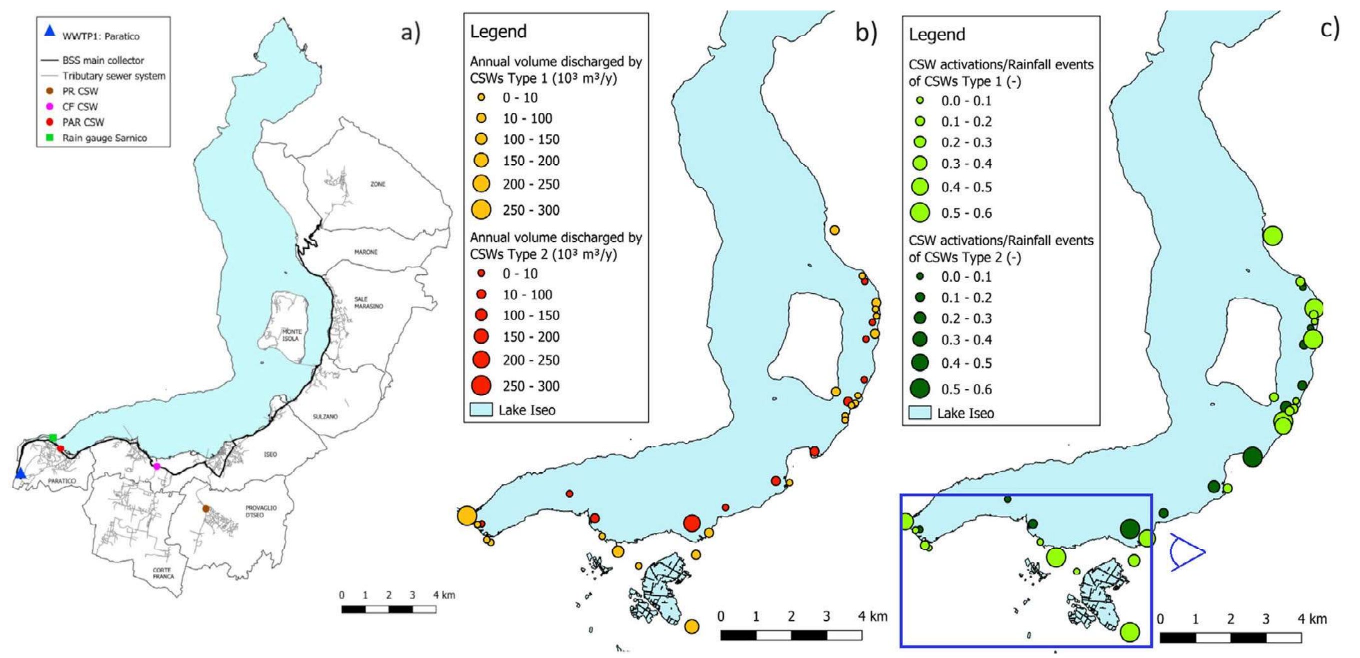

Figure 1 | (a) East main collector, tributary networks and measured combined sewer weirs (CSWs). (b) Map of the annual volumes and (c) of the activation frequency of the CSWs[1]. The blue-framed area with viewpoint is the one shown on the Hydrolink cover with Torbiere d'Iseo.

Even though the residual load from the CSOs could be considered small with respect to the overall load delivered to the lake, the local effects of these inputs can be decisive. Figure 1b-c presents the spatial distribution of the annual volume discharged by each overflow weir on the eastern side and the frequency of the CSO events, thus showing the location of places where a localized environmental impact may be expected. Here, overflowing waters provide a primary source of microbiological contamination that may hinder bathing in the lake waters as well as localized spots along the shore with an impaired habitat.

The local effects of the CSOs are particularly impacting when considering the case of the Torbiere wetland, where the load is delivered in an isolated and fragile ecosystem characterized by slow transport processes. Here, the estimated load from the CSOs was seen to contribute to the 30% of the overall nutrient load to the wetland[2] and therefore it must have played a decisive role in the ecological evolution of this ecosystem, together with the diffuse load delivered by the main inflow.

This case study provides an emblematic example of how the impact of urbanization on the quality of the surrounding environment may be underrated, even though, paradoxically, the built environment itself draws a large fraction of its economic value from the beauty of the surrounding landscape. Therefore, especially in cases where the receiving water bodies are fragile ecosystems such as lakes and wetlands, awareness of the environmental cost of urbanization is urgently needed, with a new approach that goes beyond that of "glossing over nature", recognizing instead the economic value attached to nature and to all the ecosystem services it provides.

References

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