

Water quality in the fluvial section Physicochemical and bacteriological parameters— 5th edition

Name of indicator: Physicochemical and Bacteriological
Parameters of St. Lawrence River Water
Status: Moderate in 2021–2023
Trend: Little change since 2000

Highlights

The physicochemical and bacteriological quality of the water in the St. Lawrence River was rated “moderate” in 2021–2023, with a third of stations having good water quality. Since 2000, the annual percentage of stations with “good” or “fair” water quality has remained stable, at around 80%. However, persistently high coliform concentrations have limited the overall improvement in the river’s water quality.

Problem

The freshwater portion of the St. Lawrence River not only provides ecosystem services to the human population, but it is home to an extraordinarily wide range of habitats essential for many species. The river’s main source is Lake Ontario, but it is also fed by the Ottawa River in the Montreal region and a number of other tributaries along its route, doubling its flow by the time it reaches Quebec City. In the fluvial section upstream of Lake Saint-Pierre, these water masses coexist, but do not mix for the most part, due to their distinct physicochemical composition and the river’s morphology. However, mixing increases in the section between Lake Saint-Pierre and Île d’Orléans, known as the fluvial estuary, mainly due to the tidal effect (Figure 1).

The dense human population along the St. Lawrence River puts constant pressure on the river’s water quality. The towns, cities and industries along its shores discharge wastewater into the river, while various pollutants from human activities such as agriculture enter the river through its tributaries. Despite the river’s impressive flow, it has a precarious dilution capacity, which is being exacerbated by climate change. Consequently, rigorous water quality monitoring is essential to preserve the biodiversity of the river’s ecosystems, prevent their eutrophication, and ensure the sustainability of the many services they provide to us.

Study area

The physicochemical and bacteriological quality of the river's water masses is monitored through monthly sampling. A total of 27 stations extending from Valleyfield on the upstream end to the western tip of Île d'Orléans are sampled from May to October. These stations are representative of the different water masses and stretches of the river (Figure 1).

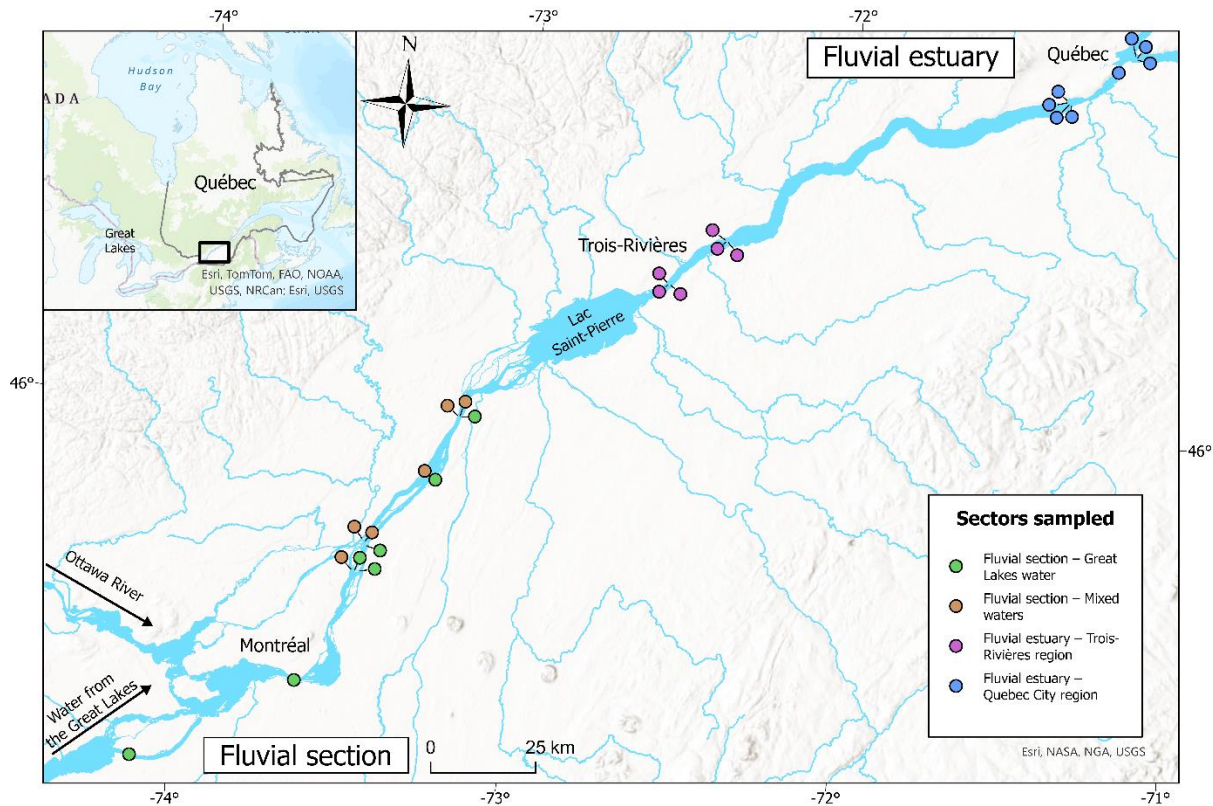


Figure 1. Map of the St. Lawrence River showing the 27 sampling stations, grouped by water mass or region. The fluvial section, located upstream of Lake Saint-Pierre, is composed of two distinct water masses: one made up of Great Lakes water and another, of a mixture of waters from the Great Lakes, the Ottawa River and the tributaries on the river's north shore. The fluvial estuary, located downstream of Lake Saint-Pierre, is under tidal influence, and is represented by stations around Trois-Rivières and Québec City.

Key measures

Water quality is assessed using the [index of bacteriological and physicochemical quality \(IQBP₅\)](#) (MELCC 2022), based on five parameters (fecal coliforms, ammonia nitrogen, nitrites and nitrates, chlorophyll α , and total phosphorus*). The results for these parameters are used to rate water quality as good, fair, questionable, poor or very poor. A station's water quality rating is determined by calculating the median of the ratings in the period selected (one year or a block of three years). The overall bacteriological and physicochemical status of the river is determined by the percentage of stations deemed to have “good” water quality out of the 27 stations monitored.

Poor	Moderate-poor	Moderate	Moderate-good	Good
< 20%	20% to 29%	30% to 39%	40% to 65%	66% and +

A supplemental assessment of water quality is provided by analyzing the frequency with which the criteria or guidelines for the IQBP₅ parameters are exceeded, as well as those for suspended solids and turbidity. Depending on the parameter being measured, the criteria target either the protection of aquatic life, prevention of water contamination, protection of recreational activities and aesthetic aspects, or prevention of eutrophication ([MELCCFP 2024](#)). The guidelines for chlorophyll α , suspended solids and turbidity correspond to thresholds below which water quality is deemed satisfactory, and are provided for information purposes (MELCC 2022).

*Since monitoring began, several modifications have been made to the method for measuring total phosphorus, which can make it difficult to draw annual comparisons. Owing to the method used between 2011 and 2020, chloride interference led to total phosphorus values being underestimated. The impact of this underestimation on the results is assessed when possible by comparing the methods in 2020 and 2022 for information purposes. However, this bias does not affect the total phosphorus values used in determining the indicator's current status (2021–2023).

Status and trends

Water quality rated “moderate” between 2021 and 2023

Between 2021 and 2023, the physicochemical and bacteriological quality of the water in the freshwater portion of the St. Lawrence was rated “moderate,” owing to the fact that only one third of the stations had a “good” water quality rating (Figure 2). Although most stations (52%) had “fair” water quality, water quality was “questionable” to “very poor” at roughly 15% of the stations. The poor water quality at these stations was due mainly to high fecal coliform concentrations.

Although water quality can vary considerably depending on the sample, an overall geographical pattern can be ascertained for the different sections of the river (Figure 2). Most “good” quality samples were obtained in the southern part of the fluvial section, at stations with Great Lakes water. However, the fluvial section also had the greatest number

of “very poor” samples, which were mainly obtained at stations located in the centre, near the north shore (mixed water masses). In the fluvial estuary, stations with “fair” or “questionable” water quality were most often found in the Trois-Rivières region, while most stations in the Quebec City region had “good” or “fair” water quality (Figure 2).

Samples with “questionable” or “very poor” water quality were generally characterized by high fecal coliform concentrations. In the Quebec City region, however, the higher concentrations of chlorophyll α in some samples were responsible for their “questionable” rating. Similar to total phosphorus, chlorophyll α concentration is used as an indicator of eutrophication of aquatic ecosystems.

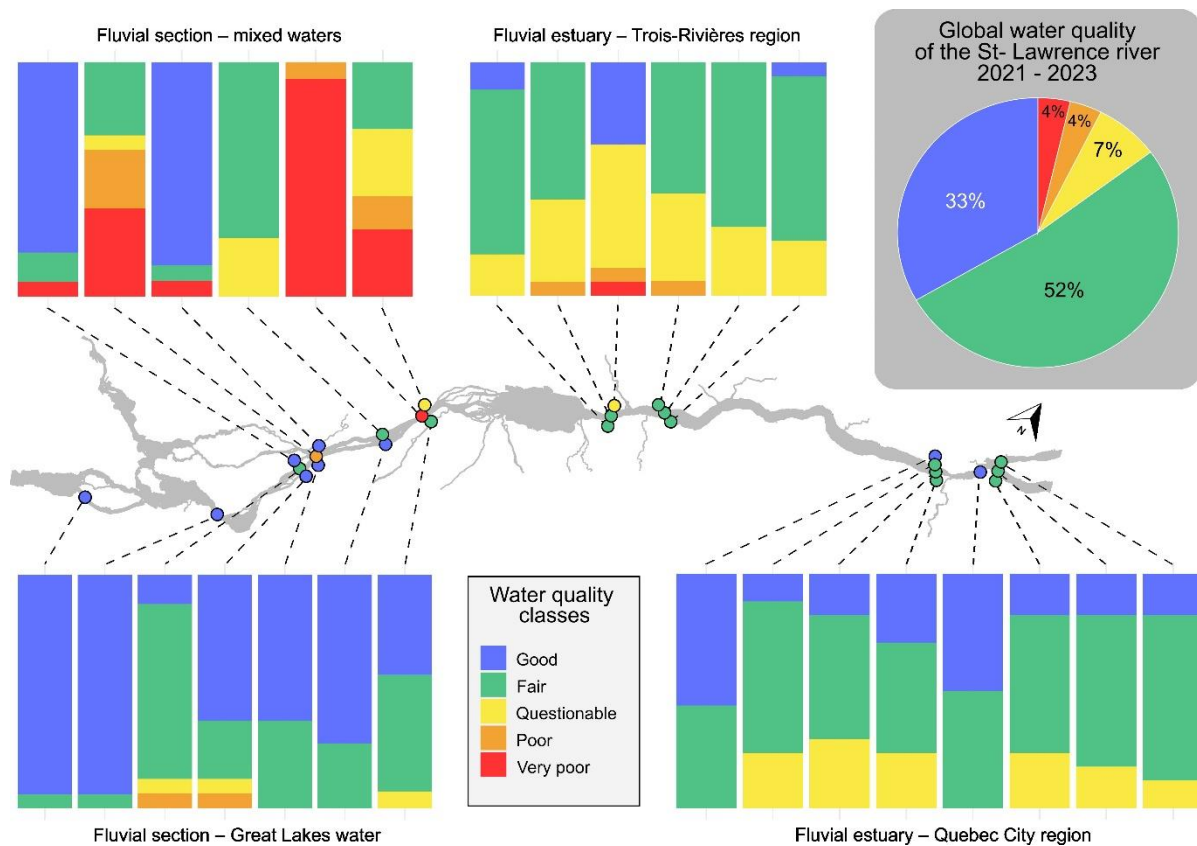


Figure 2. *Distribution of bacteriological and physicochemical water quality ratings in the St. Lawrence River between 2021 and 2023.*

The bar graphs show the distribution of the water quality ratings for the samples collected between 2021 and 2023 at each of the 27 stations, which are grouped together by water mass or region. Each column is linked to a station, its location shown on a representation of the river. The colour of the dot representing the station shows the most frequent quality rating (the median), while the pie chart shows the distribution of median ratings for all 27 stations between 2021 and 2023.

Frequent exceedances of water quality criteria

Between 2021 and 2023, the most frequent exceedances of the criteria or guidelines involved the fecal coliform and turbidity parameters (Figure 3). Nearly half of the samples taken during this period exceeded the criterion or guideline for these parameters,

representing all water masses and regions of the river. Roughly one out of every five samples exceeded the criteria or guidelines for concentrations of total phosphorus and suspended solids, while the criteria related to dissolved nitrogen (NO_x and NH_3) were very rarely exceeded. Although nitrogen nutrient concentrations in the fluvial section of the St. Lawrence do not appear to be worrisome in terms of water quality, they can affect downstream processes, notably in the Estuary and Gulf, by exacerbating the issues of low oxygen conditions and acidification of the deep waters, which have worsened over time (Blais et al. 2021).

Fluvial section

In the fluvial section, the stations receiving Great Lakes water had the lowest frequency of exceedance of the criteria or guidelines (Figure 3), while those with the highest frequency were in mixed waters (Figure 3). At the latter, fecal coliforms exceeded the criterion for activities involving direct contact with water by a factor of over 12 on average. In the case of the criterion for activities involving indirect contact with water, the magnitude of exceedance was four times the criterion on average. Since a number of stations in the fluvial section are located directly downstream of outlets discharging non-disinfected wastewater from the Montreal urban agglomeration, these frequent exceedances of the water quality criteria and their high magnitude are hardly surprising.

Fluvial estuary

A similar trend was found in the fluvial estuary, with samples frequently exceeding the criteria or guidelines for fecal coliforms and turbidity. However, on average, the exceedances were of lower magnitude than those recorded in the mixed waters of the fluvial section (Figure 3). The most frequent exceedances of the turbidity and suspended solids guidelines, as well as the total phosphorus criterion, were observed at the stations near Quebec City. These more frequent exceedances for the physicochemical parameters in the fluvial estuary could be caused by the progressive accumulation, from upstream to downstream, of the loads from the river's main tributaries (Grenier 2024; Patoine 2017).

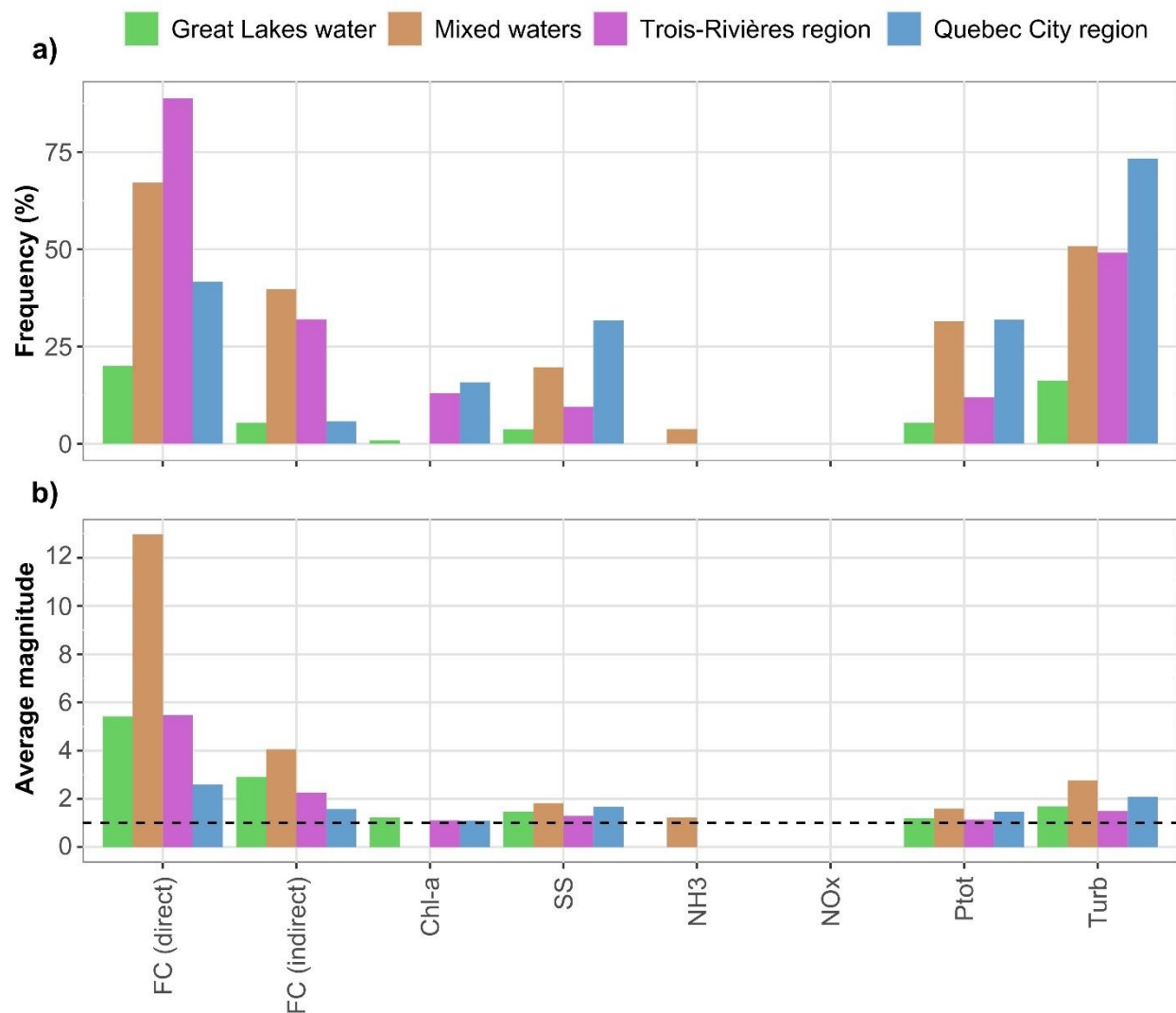


Figure 3. Frequency and magnitude of exceedance of criteria or guidelines for the different physicochemical and bacteriological parameters measured between 2021 and 2023.

(a) Frequency of exceedance of the criteria or guidelines (as a percentage; %) for fecal coliforms (FC; direct and indirect contact criteria: 200 and 1,000 CFU/100 mL), active chlorophyll α (Chl- α : 4.75 μ g/L), suspended solids (SS: 13 mg/L), ammonia nitrogen (NH₃: 0.2 mg N/L), nitrites and nitrates (NO_x: 3 mg N/L), total phosphorus (P-tot: 0.03 mg/L) and turbidity (Turb: 5.2 NTU). Each colour represents a sector. (b) Average magnitude of exceedance of the criteria or guidelines for the same parameters by sector. The dashed line represents the value of 1, i.e., the threshold for exceedance of the criterion or guideline.

Little change in water quality since 2000

Little change has occurred in physicochemical and bacteriological water quality in the St. Lawrence River since 2000 (Figure 4). The annual percentages of stations with “good” and “fair” water quality ratings vary, since a number of stations have IQBP₅ values near the threshold between these two classes. In addition, changes in the measurement of total phosphorus introduced a bias between 2011 and 2020, causing uncertainty over the proportions of these two classes. Despite the variability from year to year, around 80% of stations have “good” or “fair” water quality. In addition, a significant declining trend in the percentage of stations with “very poor” ratings has been observed (regression of the percentage of stations as a function of time, slope statistically different from 0; $p < 0.001$). The number of stations rated “very poor” decreased from two or three in the early 2000s to a single station since 2017.

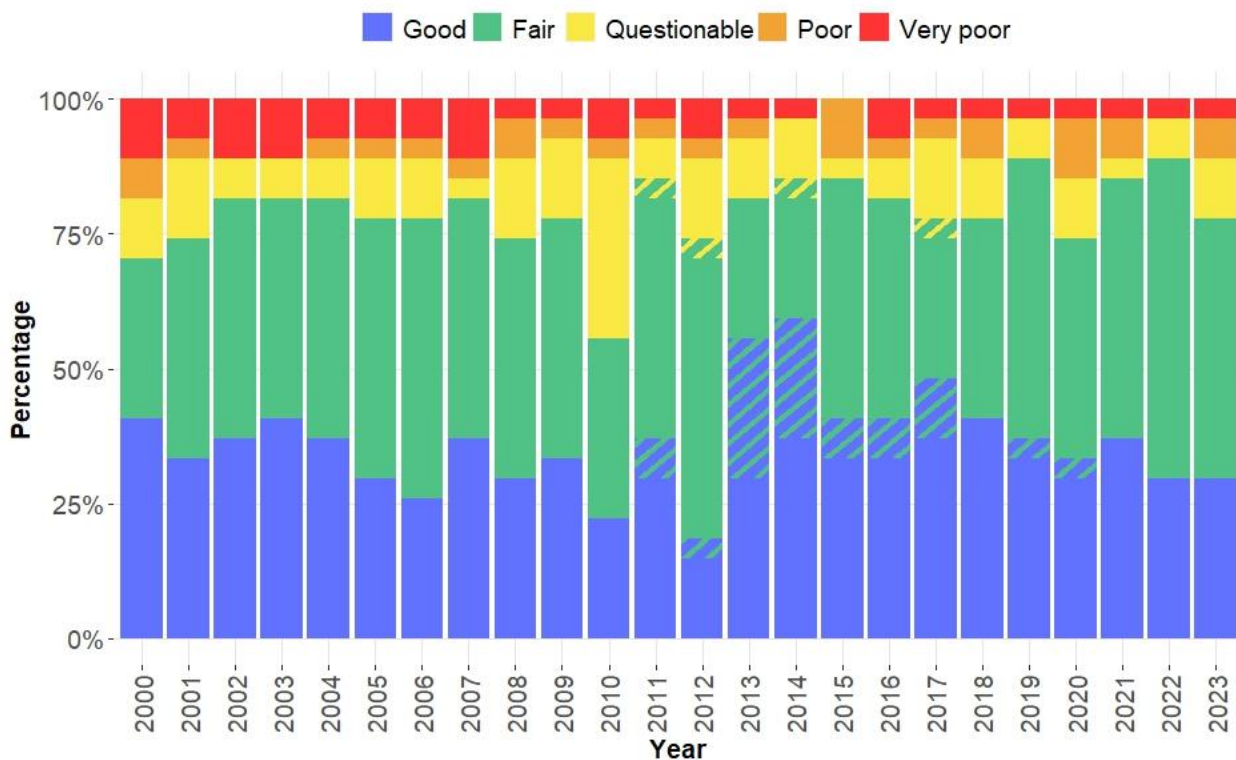


Figure 4. *Changes in the annual distribution of water quality ratings since 2000.*

Changes in the method used for measuring total phosphorus could affect IQBP₅ values and the distribution of annual ratings by station during the 2011–2020 period. For information purposes, stations in the region with uncertain water quality ratings are represented by striped bars in the graph.

Persistent fecal coliform pollution and changes in other parameters

Since the year 2000, fecal coliform levels have frequently exceeded the criterion for direct contact activities, in roughly 40% to 50% of the samples (Figure 5) at all stations. Nevertheless, a decline has been noted in the average magnitude of these exceedances, from roughly a factor of nine to a factor of six (regression of the average magnitude as a function of time, slope statistically different from 0; $p < 0.001$). Nevertheless, the average

exceedance magnitude still remains very high, which indicates that more improvements will be needed to achieve good water quality.

Exceedances of the chlorophyll α guideline appear to be more frequent beginning in 2009. Although not statistically significant at the 5% level (but significant at the 10% level; $p = 0.09$), this increase appears to be more pronounced in the fluvial estuary. The higher concentrations of suspended algae downstream of Lake Saint-Pierre could be linked to changes in this ecosystem observed in the last 20 years, for example, the decline in the presence of submerged aquatic vegetation (Laporte et al. 2023).

The frequency of exceedance of the turbidity guideline has varied considerably since 2000, increasing until 2010 and then dipping slightly to stabilize at around 40% (Figure 5). A number of factors can cause variations in turbidity in the St. Lawrence, notably loads from the tributaries (Grenier 2024) and shoreline erosion (Richard 2010), which increase suspended solids and affect turbidity.

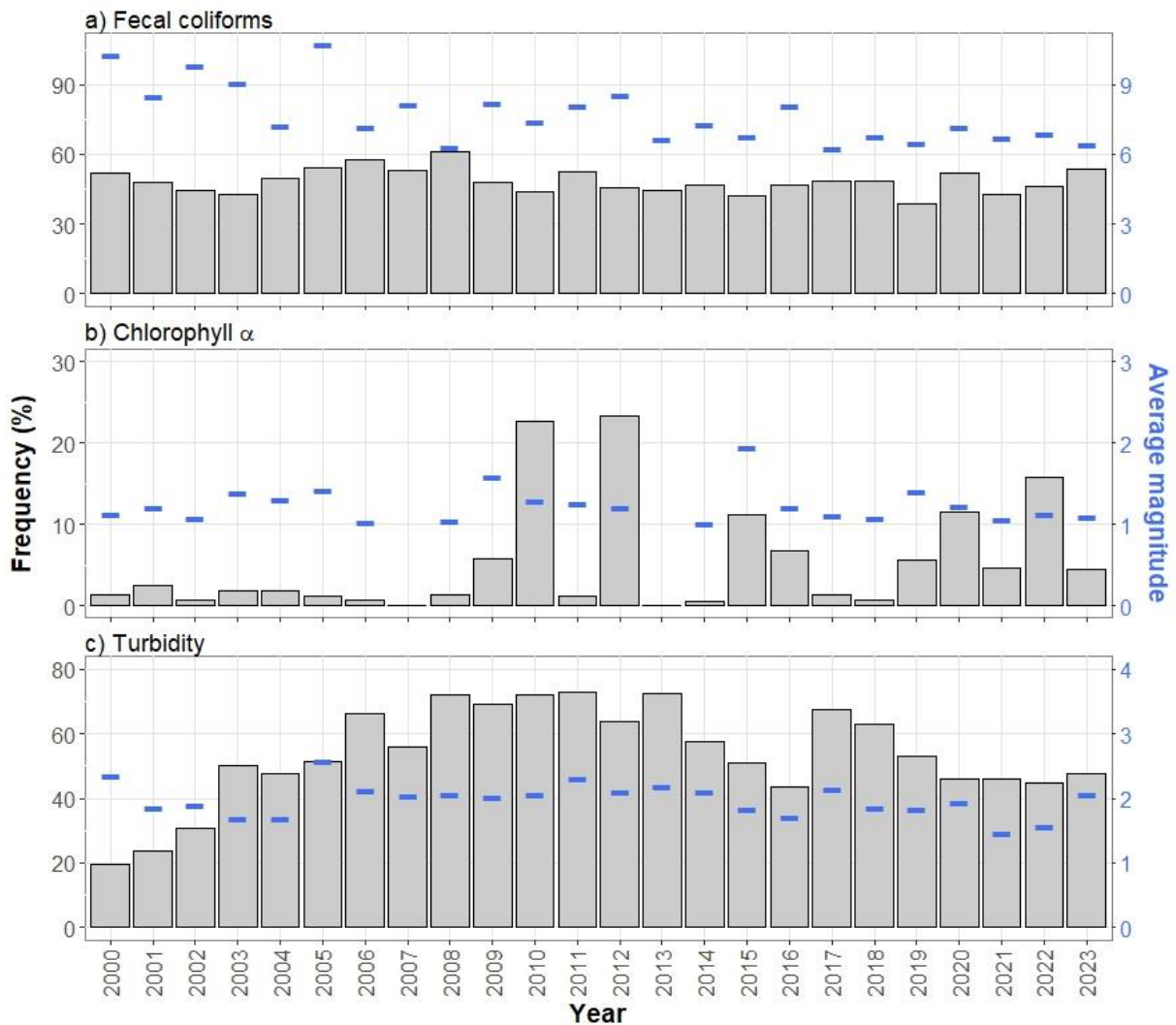


Figure 5. Frequency and average magnitude of exceedance of the water quality criteria or guidelines for three parameters at all the stations in the St. Lawrence since 2000.

(a) For fecal coliforms, the direct contact criterion is 200 CFU/100 mL; (b) for chlorophyll α , the guideline is 4.75 $\mu\text{g/L}$; and (c) for turbidity, the guideline is 5.2 NTU (nephelometric turbidity units). Exceedance frequencies are shown on the left axis as percentages, and their average magnitude is shown in blue on the right axis.

Outlook

The physicochemical and bacterial quality of the water masses in the St. Lawrence provides insight into not only the health of the river's ecosystems and the quality of the ecological services they provide, but also the management of human activities in the river's watershed. For example, fecal coliform-related criteria are still exceeded fairly often in the river, which limits uses significantly. Excess nutrients in the river must also be monitored, since an increased nutrient load could be a sign of the degradation of river ecosystems, as well as contribute to low-oxygen conditions and acidification in the St. Lawrence Estuary and Gulf. These findings also highlight the necessity of continuing the efforts to reduce the sources of pollution caused by human activities. Therefore, monitoring water quality in the St. Lawrence is essential to detect changes in the management of human activities in its watershed, as well as the effects of climate change.

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For more information

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