SDG Indicator 6.3.2 Technical Guidance Document No. 5: Biological Monitoring

This document introduces the concept of biological water quality monitoring for SDG Indicator 6.3.2 reporting. This is a companion document to [Introduction to SDG Indicator 6.3.2][1] and [Technical Document Level 2 Monitoring][2] that can be found on the [SDG Water Quality Hub].

Recognising that biological approaches are well suited to: track long-term ambient water quality trends; are sensitive to stressors that are not always detected by physical or chemical monitoring; and, support ecosystem-based health approaches.

This document provides initial direction for countries looking to initiate biological monitoring, and also guidance on how to incorporate existing biological data into the SDG reporting framework.

Introduction

SDG Indicator 6.3.2 allows Member States to track progress towards Target 6.3 which includes improving water quality. The indicator is divided into Level 1 and Level 2 reporting. Level 1 is the required component of the indicator framework that ensures the global comparability of the indicator by prescribing the measurement of standardised basic core components. The indicator methodology at Level 1 achieves this by using simple to measure characteristics of water that represent pressures and responses that are relevant everywhere. The parameters included are: nutrients (nitrogen and phosphorus); oxygen; salinity and pH.

Reporting at Level 2 is an additional option that provides the flexibility for countries to report on water quality alterations that may focus on issues of national or regional relevance or allow for approaches that go beyond the basic physical and chemical parameters – biological monitoring is included as a Level 2 approach. A comparison of physical and chemical water parameters and biological approaches is included in Annex 1.

This document is relevant because globally, routine ambient water quality monitoring programmes rely primarily on measurements of physical and chemical characteristics to determine suitability for specific uses such as drinking, irrigation, or industry. Increasingly, there is recognition that these measurements can be complemented by ecosystem health approaches, which capture biological responses to multiple stressors and provide a more integrated perspective on the sustainability of these services. Yet, many countries either do not have nationally-approved biological monitoring systems (Simaika *et al.*, 2024), or the biological monitoring results are not consistently used in water policy decision-making (BBMA 2024b; Kelly *et al.*, 2025). Providing guidance on how to incorporate biological data into the SDG reporting framework will raise the profile of this important approach to water quality monitoring, and will improve the evidence base for decision making.

Overview of Biological Methods and Approaches

Biological assessment approaches build on the fact that aquatic organisms show measurable responses to environmental change, ranging from physiological stress and reduced growth or reproduction, to shifts in populations and community structure and function, making them effective indicators of ecosystem health. There are methods which are more 'general'

[1] https://wwqa.info/knowledge-center/sdg632/SDG632_Introduction-to-the-Methodology
[2] https://wwqa.info/knowledge-center/sdg632/SDG632_Technical-Guidance-Document-No4-Level-2-Reporting

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and useful to identify multiple pressures at the same time, but there are also methods that are pressure-specific related to eutrophication or acidification. Pressure-specific methods can be useful tools that express actual effects of the pressures - for example, nutrients will not tell you whether the water body is safe to use but a phytoplankton bloom will.

It is important to recognise the role of habitat when considering biological approaches. Many freshwater ecosystems have been heavily altered including changes to water flow, disrupted sediment transport as well as physical modifications often caused by human activities such as damming, channel straightening, and land-use changes. These shifts affect river shape, depth, speed, and the materials within the bed, influencing everything from floodplains to biota. In such cases water bodies may have excellent water quality as defined by level 1 reporting (low nutrients, high oxygen, and expected pH and conductivity) but would exhibit low biological value compared more natural condition water body with a diverse mosaic of habitats.

Depending on the taxonomic resolution required and the organism group under study, biological approaches can, once established, be less costly than chemical analyses, as they typically avoid the need for expensive equipment. However, they may demand greater investment in training field personnel and, in some cases, taxonomic expertise.

Table 1 below summarises the major biological groups that can be used along with examples of indices and methods and the strengths and limitations of each.

Table 1: Summary table of main groups that can be used for biological monitoring of fresh waters

Biological Group	Typical Indices and Methods	Strengths	Limitations	Suitable Water Bodies	Indicative Pressures Detected
Macro-invertebrates	Order/family/genus-level indices (e.g., EPT, BMWP/ASPT, SIGNAL, SASS, Q-values, tolerance values); multimetric IBIs; standardised kick/sweep sampling	Cost-effective, widely adopted, sensitive to organic enrichment and oxygen stress, long term change	Requires taxonomic skills for field ID to coarse level; lab microscopy for genus/species; seasonal/flow effects	Rivers, streams, lakes	Organic load, nutrients, oxygen depletion, sedimentation
Phytoplankton	Chlorophyll-a, cyanobacteria abundance, compositional indices; integrated tube or depth-stratified sampling	Direct link to trophic state; responsive in lakes/reservoirs	High temporal variability; needs seasonal sampling; requires taxonomic skills	Lakes, reservoirs, slow rivers	Nutrients, light/climate interactions
Macrophytes	Macrophyte Index for Rivers (MIR), community composition, % cover; wade/boat surveys	Reflects habitat and longer-term nutrient status	Slower response; influenced by hydromorphology	Rivers, lakes, wetlands	Habitat alteration, nutrients, flow regime
Diatoms	Trophic Diatom Index, IPS, regional diatom metrics; rock/cobble scrapes and microscopy	Rapid responders to nutrients; good for eutrophication gradients	Lab microscopy and reference floras needed; requires taxonomic skills	Rivers, lakes	Nutrient enrichment, conductivity, acidity
Fish Communities	Index of Biotic Integrity (IBI), species/tolerance guilds; electrofishing / netting	Integrates multiple pressures; socially salient	Resource-intensive; permits/logistics	Larger rivers, lakes	Habitat fragmentation, flow alteration, cumulative pollution
Zooplankton	Species composition, diversity indices, biomass ratios (e.g., rotifers vs. cladocerans)	Sensitive to trophic changes; good indicators of eutrophication and food-web alterations	Requires microscopy and seasonal sampling; influenced by fish predation; requires taxonomic skills	Lakes and reservoirs	Nutrient enrichment, trophic imbalance, toxic algal blooms

Guidance for Countries Developing Biological Monitoring

Deciding on whether biological monitoring approaches are suitable for each national or regional context can be informed by following the decision tree represented in Figure 1.

The first question on feasibility refers to whether the capacity, resources, and enabling conditions to implement water quality biological monitoring are in place. For example, does the national authority have the mandate, trained staff, and organisational structures to implement a biological monitoring program? Also, it is important to identify whether there is, or could be, funding available to support developing this capacity that would include regular monitoring, training, the development of regionally adapted taxonomic keys as well as data management.

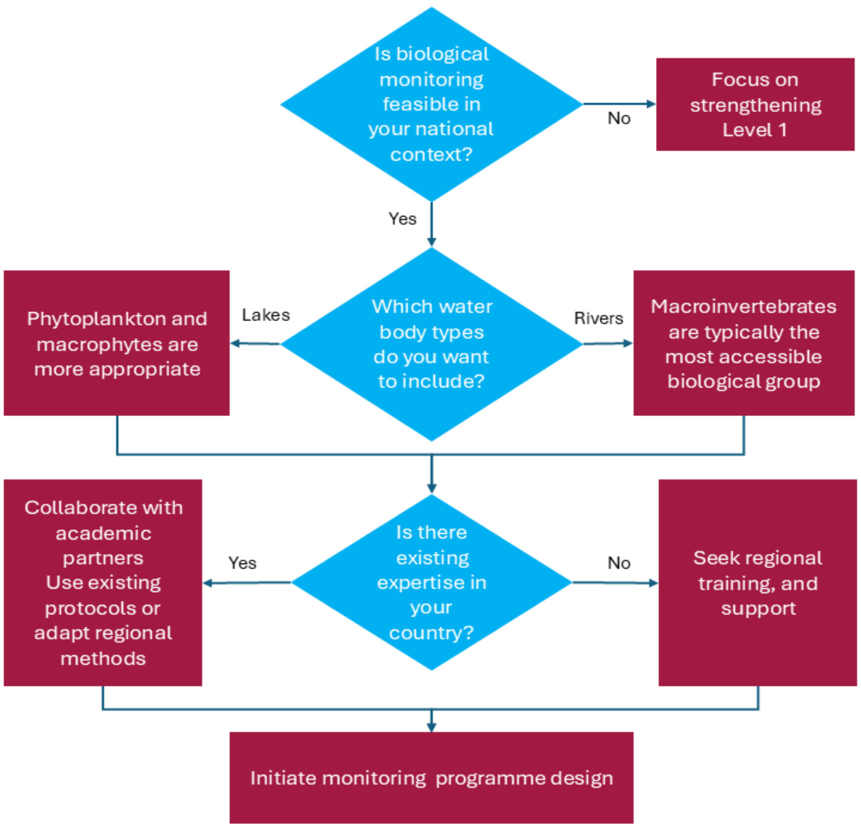

Figure 1: Decision tree to help determine the initial course of action to develop biological monitoring capacity

Next steps

Once the decision to develop biological monitoring has been adopted, a phased implementation is recommended.

For rivers, **macroinvertebrates** are the most pragmatic entry point because methods are accessible, there is a broad evidence base, and they show a strong sensitivity to organic pollution, nutrient and sediment inputs, and long- term physical, chemical and biological changes. For lakes, **phytoplankton** provide the most suitable starting point, as they respond rapidly to nutrient enrichment, are relatively straightforward to sample, and have well-established assessment methods. Over time, countries may expand to include macrophytes and zooplankton for lakes, which offer complementary insights into ecological condition and long-term changes.

To support the adoption of biological monitoring approaches, several practical next steps are recommended.

- **Countries should leverage existing regional protocols** such as the European Union's Water Framework Directive or the United States Environmental Protection Agency's Rapid Bioassessment Protocols. These established frameworks provide tested methodologies, quality assurance procedures, and reference materials that can be adapted to local contexts, reducing the need to develop entirely new systems from scratch.
- **Capacity building is essential.** This includes training technicians in field sampling techniques and taxonomic identification, as well as developing national or regional reference conditions against which monitoring results can be compared. Building technical expertise and institutional knowledge ensures that monitoring programs are both reliable and sustainable over the long-term. For advice on capacity development opportunities, contact the SDG 632 Help Desk.
- **Pilot projects should be initiated at a local scale** before expanding nationally. Beginning with a few representative sites allows methods to be tested, protocols to be refined, as well as logistical challenges to be identified in a controlled setting. Lessons learned from these pilots can then inform broader implementation, ensuring that national programs are both cost-effective and scientifically robust.

These steps provide a pathway to establish credible, cost-effective, and scientifically robust biological monitoring programs.

Guidance for Countries Already Collecting Biological Data

Efforts to integrate existing biological monitoring programme data into SDG reporting workflows should follow the steps outlined below to align with the existing monitoring and reporting framework. Details can be found in the Introduction to SDG Indicator 6.3.2 document.

Delineate Water bodies and Reporting Basin Districts

Countries that are already reporting at Level 1 will have water bodies and Reporting Basin Districts (RBD) delineated. These same ones should be applied to the biological monitoring programme.

Biological approaches are relevant for river and lake water bodies only. Water bodies are defined as discrete hydrological units and it is these units that are classified as being either 'good' or 'not good' water quality. It is at this local level that impacts of poor water quality are felt, and where actions to improve quality are realised. River water bodies are defined as small tributaries or sections of river along the main channel between two confluences. Lake water bodies are usually easier to define, and encompass the whole lake extent.

Ideally, river water bodies should be delineated to ensure they are homogenous in terms of water quality. This allows the water body to be classified as good or not using fewer monitoring stations. Each lake water body may require many monitoring locations to ensure that quality can be classified reliably (refer to Introduction Document[3]).

RBD are based on river basins. Many countries have their river basin-based management units already defined. Such units are often used for national reporting on many aspects of water and sanitation. Countries are encouraged to apply these same units for SDG Indicator 6.3.2 reporting to ensure that linkages between activities that affect water quality, such as waste water generation and treatment can be linked to water quality.

Set Targets

SDG Indicator 6.3.2 uses a target-based approach to classify water quality. This means that the data are compared against a target that represents 'good ambient water quality'. Targets may be water quality standards that are defined by national legislation or they may be derived from knowledge of the natural or baseline status of water bodies.

In practice, for biological approaches this can be achieved by defining a desired or target condition that is specific to the approach being used that would reflect minimally disturbed or high-quality sites. For example, a biological index score derived from such sites, could be used as the 'target' for monitoring sites – for a particular monitoring event, a measurement that returned an index score equal to or higher than the defined 'target' would mean that 'good' ambient water quality was recorded. There is a technical document available that provides more detailed information on the target setting process.

Classify Water bodies

Classification using the Level 1 approach relies upon an 80 per cent compliance – a water body is classified as 'good' water quality if 80 per cent or more of the measurements meet their respective targets. This 80 per cent compliance approach may be difficult to apply to biological approaches because the number of data points collected are usually fewer than for physical and chemical approaches. For example, quarterly analysis for the five core parameters (N, P, EC, DO and pH) over the recommended three-year data period for a single monitoring location would result in 60 measurements that are each compared against their respective targets. If 80 per cent or more (≥48) of those measurements meet their targets, the water body would be classified as 'good'. For the same river water body, annual macroinvertebrate sampling for example (one per year), would generate only three measurements, which is insufficient to apply the 80 per cent compliance threshold. This can be overcome for several biological approaches because they use an index, and a predetermined index score could be used as the 'good' threshold. If a graduated classification system is used, a boundary between two classes could be chosen to represent 'good' water quality.

For methods that do not employ an index system, it is recommended that a statistically derived value from the last three years, such as the mode (most common) is used. This will be method-dependent and should account for the frequency and variability of the data collected.

Aligning existing classification systems

The per cent compliance or a statistical value based on the index scores provides more nuanced information than the binary 'good' versus 'not good' of this SDG indicator. This additional information is of value for water resource management beyond SDG reporting, and aligns with well-established systems such as the European Union's Water Framework Directive which classifies surface water bodies into five ecological status classes to assess ecosystem health: high, good, moderate, poor, and bad. In this example, using the good/moderate boundary would be suitable to reflect 'good' water quality in the SDG framework (Figure 2).

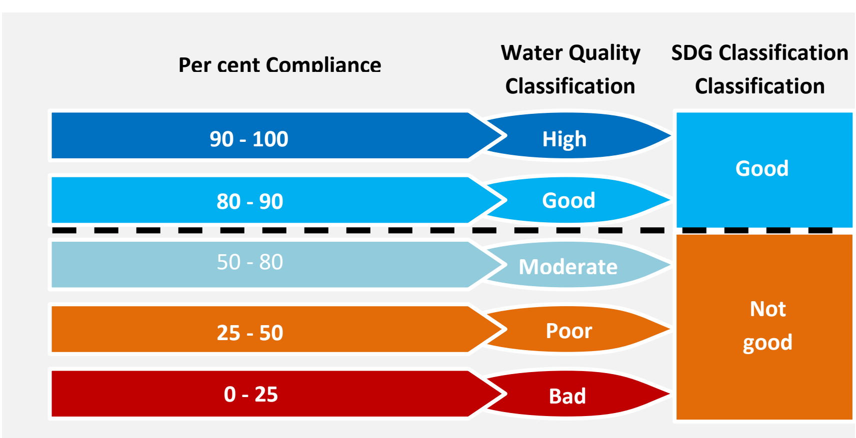

Figure 2: Example of relationship between per cent compliance, existing water quality classification system and how this could be translated into the binary SDG classification

This additional information is especially relevant in determining the optimum management pathway for a particular water body. The approach to management of a water body that scores 79 (very close to 'good' classification) could be considerably different from one that scores 5 (very far from 'good' classification).

Combining Biological Monitoring indicator with Level 1 SDG indicator 6.3.2 information

The biological information can be used either to create a standalone biological water quality classification, or combined with Level 1 physico-chemical data to provide a classification that is more comprehensive than either approach alone. For the latter, the monitoring data must be co-located and represent the same monitoring station.

Where co-located data are available, a '**one out, all out**' (OOAO) approach should be applied to give the overall water body classification. For a water body to be classified as 'good' ambient water quality, each separate component must return a 'good' classification. This approach follows the European Water Framework Directive 2000/60/EC (WFD) approach which uses multiple quality elements to classify water body status, including biological approaches. Each element is considered separately and a OOAO approach is applied (EEA, 2018). A water body is assigned an overall status based on the lowest status for the quality elements monitored within that water body (Figure 3). This approach is recommended for combination of biological data with Level 1 general physico-chemical data.

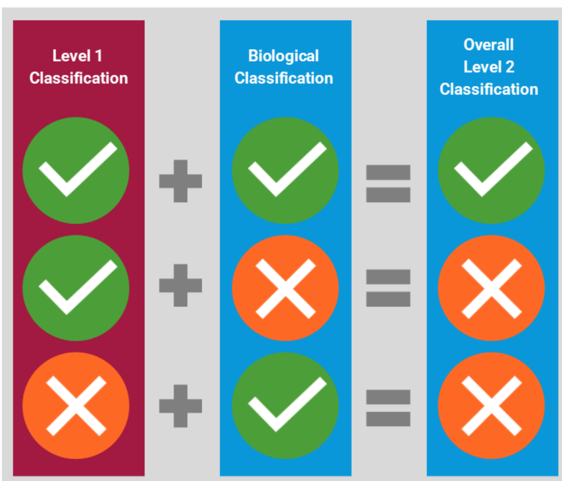

Figure 3: Schematic showing combination of a Level 1 classification and a biological classification at the water body level using the 'one out, all out' approach.

Reporting Biological Monitoring Data

As for Level 1 reporting, there is an [Excel-based reporting template] that is available for a Level 2 submission through the SDG Water Quality Hub. It is important to highlight that only Level 1 reporting data are collated by the United Nations Statistical Division (UNSD). Countries that report at Level 2 will have two national indicator scores and currently, the Level 2 indicator information remains with UNEP and will be shared through the [SDG Water Quality Hub].

Level 2 submissions are not constrained by the three-year reporting cycle of Level 1 and countries can choose to report either in parallel or in sequence to their Level 1 submission.

CITIZEN SCIENCE AND BIOLOGICAL MONITORING

Citizen science refers to the involvement of non-professional scientists in the scientific process. Data generated by citizen scientists are widely used in environmental and biological monitoring projects. Incorporating citizen science approaches to water quality monitoring provides multiple benefits for efforts to manage water resources, both from a data collection and community engagement perspectives. Citizen science initiatives offer a low-cost, high-impact way to:

- **expand monitoring coverage** and data temporal resolution in areas not regularly sampled by national agencies;
- **provides a means to engage communities** in water resource management; and,
- **builds awareness and education** around aquatic ecosystems and water quality issues.

Through the *WWQA Workstream on Citizen Science*, several countries are already combining citizen-generated data with national monitoring programme data for Level 1 reporting. In 2023, two countries: Sierra Leone and Zambia, used these data directly for SDG reporting (UNEP 2024) and several more are following this approach. There is also a technical document[4] on integrating citizen-generated data for SDG Indicator 6.3.2 reporting.

Globally, several citizen-based biological approaches are well established and could offer opportunities to incorporate citizen-generated data into SDG reporting. Most notably, the freshwater stream biomonitoring method miniSASS, (mini stream assessment scoring system) developed in South Africa, based on the South African Scoring System (SASS), has been tested globally (Graham and Taylor, 2018) and the feasibility for SDG reporting has already been trialled (Taylor et al, 2022). The miniSASS tool is a simplified macroinvertebrate-based stream health index designed for use by schools, communities, and citizen groups.

Citizen science approaches are especially valuable where national ministries have limited field capacity but universities, schools, or NGOs are active. **Partnering with universities, NGOs** that may be operating citizen science projects offers a potential route to developing a **national programme.** Efforts will require the formulation of guidance documents, protocols and feedback loops so citizen data informs formal monitoring and vice versa. Essential to the success of any citizen science initiative is the recognition of contributions in all outputs and outreach materials.

Figure 4 lists four entry points and action pathways based on the availability of national and citizen-generated biological monitoring data. For example, a country that has both national and citizen-generated data available should focus on connecting these initiatives and test methods of data integration (WWQA, 2024). The *WWQA Workstream on Citizen Science* convenes a broad range of experts and practitioners that can provide guidance and support to countries interested in developing this approach. Contact can be made through WWQA-Coordination@un.org.

[4] https://wwqa.info/knowledge-center/sdg632/SDG632_Technical Guidance-Document-No6-Citizen-Science

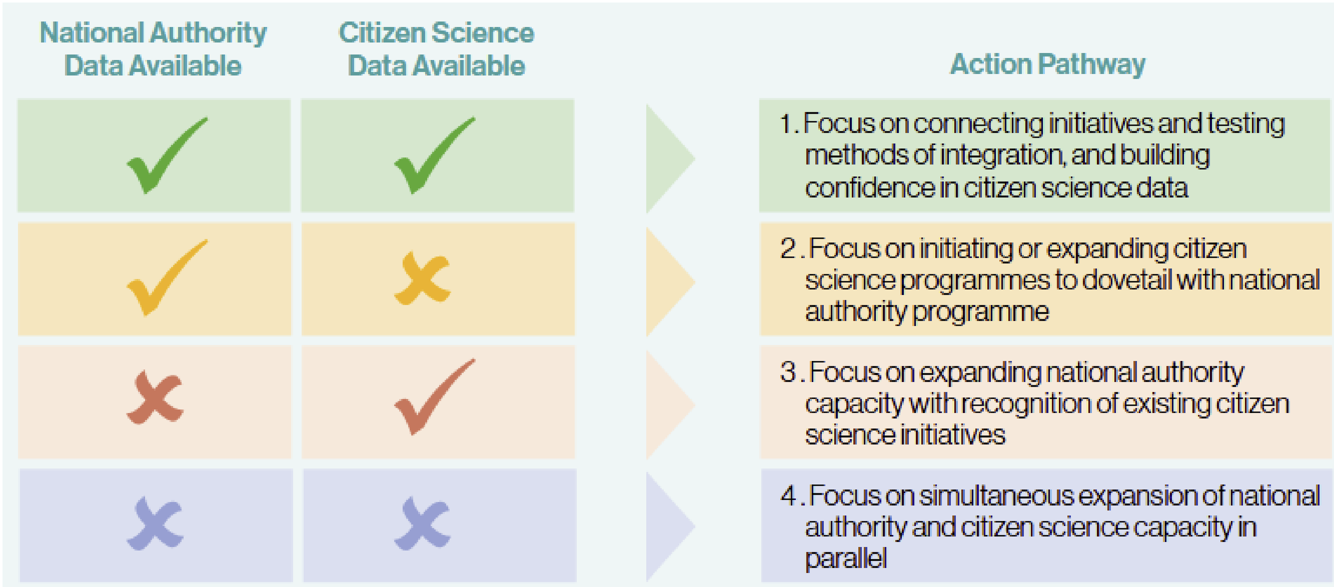

Figure 4: List of four action pathways based on national agency monitoring capacity and existing citizen science projects (WWQA, 2024)

SUMMARY

Globally, physical and chemical approaches to ambient water quality monitoring dominate, despite the multiple benefits of biological monitoring. Biological approaches can provide important additional information and better help to track threats to freshwater ecosystems and the services they provide.

This document provides a starting point for countries that have identified biological monitoring as a means to fill water resource management information needs, yet currently have no active monitoring programme. In addition, for countries that use biological monitoring already, this document outlines how to incorporate data generated into SDG Indicator 6.3.2 reporting as a Level 2 submission.

Further Information

Below is a list of key documents that elaborate on the concepts presented.

For all queries please contact UNEP's SDG 632 Help Desk at sdg632@un.org.

Relevant SDG Methodology and Technical Documents

- SDG Indicator 6.3.2 Introductory document: https://wwqa.info/knowledge-center/sdg632/SDG632_Introduction-to-the-Methodology
- SDG Indicator 6.3.2 Level 2 Technical document: https://wwqa.info/knowledge-center/sdg632/SDG632_Technical-Guidance-Document-No4-Level-2-Reporting
- BBMA Policy Brief: Bridging the global data gap by integrating biomonitoring in water quality monitoring https://ihedelftrepository.contentdm.oclc.org/digital/collection/p21063coll3/id/22447
- BBMA Technical Paper: Integrating bioassessment in the Global Sustainability Agenda https://ihedelftrepository.contentdm.oclc.org/digital/collection/p21063coll3/id/22544

Resources for Countries Initiating Biological Monitoring

- Key guidance documents/ manuals
  - European Union Water Framework Directive: https://environment.ec.europa.eu/topics/water/water-framework-directive_en
  - United Nations Environment Programme (2024). Freshwater Quality Monitoring with Biota - Technical Guidance https://wedocs.unep.org/handle/20.500.11822/44817
  - UNEP has published "A Framework for Freshwater Ecosystem Management" in 4 volumes, https://www.unep.org/resources/publication/framework-freshwater-ecosystem-management
  - US EPA https://www.epa.gov/sites/default/files/2018-10/documents/primer-using-biological-assessments.pdf
- Online courses available
  - UNEP GEMS/Water - https://elearning.unep.org/course/index.php?categoryid=29

List of Relevant Citizen Science Projects and Resources

- Useful Projects and Initiatives
  - UK Riverfly Monitoring Initiative is monitoring over 4,600 sites on watercourses across the UK on a monthly basis (Brooks et al. 2019): https://www.journals.uchicago.edu/doi/abs/10.1086/703397?journalCode=fws
    - Projects Overview — The Riverfly Partnership
  - miniSASS: Citizen science tool for monitoring the water quality and health of stream and river systems
    - https://minisass.org.
  - Bloomin'Algae: A citizen science app for reporting the presence of blue-green algae,
    - https://www.ceh.ac.uk/our-science/projects/bloomin-algae
- Useful academic papers:
  - Fore, Leska & Paulsen, Kit & O'Laughlin, Kate. (2001). Assessing the performance of volunteers in monitoring streams. Freshwater Biology. 46. 109 - 123. 10.1111/j.1365-2427.2001.00640.x. https://www.researchgate.net/publication/227644070

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Case Studies

- Water State Agency of São Paulo (CETESB): integrated biomonitoring system
- European WFD
- South Africa SASS
- miniSASS
- Riverfly - received

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Annex 1

Comparison of biological monitoring with physical and chemical approaches based on key criteria (adapted from BBMA 2024).

Physical and Chemical Monitoring	Biological Monitoring
Ability to identify impact of distinct events affecting freshwater bodies	
Provides data on specific chemical conditions/pollutants in surface water bodies over time and space. Data mostly non-continuous, meaning they exist as single data points that do not allow the quantification of cumulative impacts. Data reflects shorter time scales and more immediate spatial surroundings; data are mostly restricted to reflect rapid changes resulting from specific events or remedial actions. Information gives direct evidence of stressors potentially causing biological degradation.	Provides data on the cumulative biological/ecological responses to environmental conditions in surface water bodies over time and space. Data obtained are cumulative and integrative; organisms are continuously exposed to all stressors and integrate the effects of possible long-term exposure after specific events affecting water quality, even if variables monitored return to normal. Data reflect longer temporal scales and are well suited for reflecting watershed-scale, cumulative ecosystem responses.
Ability to apply data directly to human health and identify ‘emerging’ pollutants	
Data are directly applicable to quantifying human health and ecological risk. Physical and chemical monitoring cannot detect biologically significant concentrations of important contaminants whose impacts are only now starting to be monitored (e.g., polychlorinated biphenyls, PCBs).	Data reflect actual exposure to and biological activity of contaminants; rather than theoretical (often worst case) impacts extrapolated from chemical data. Data can detect biologically significant concentrations of some contaminants; data reflect suitability of the habitat for a healthy biota; habitat is characterised as those cumulative physical, chemical, or biological features supporting biotic survival and reproduction.
Information Value	
Yields numerous data points per sample (on various physical and chemical parameters observed), which are relatively inexpensive per data point, but have low information value per data point.	Generates fewer data points that can be more expensive and require expert analysis, yet each offers high integrative value. Emerging technologies may ease processing but expertise remains essential.
Ability to provide water quality data based on flow variation	
Data are affected by flow variations (storms, seasonal, wet vs dry years, etc.) so that e.g., wet years can cause diluting/concentrating effects impacting temporal comparability without access to corresponding rainfall data.	Data can be affected by flow and other environmental variation over time, but with long-term data normalisation and comparison to reference sites, means data are less affected. The integrative nature of data can often reduce the influence of flow variation on interpretation of environmental assessments.
Endpoint state	
Can provide an endpoint; for example when all physical and chemical water quality parameters comply with environmental standards.	Can provide an endpoint for example when data indicates ecological recovery by assessing whether aquatic communities reflect a healthy, functioning ecosystem.