FACTSHEET ON WATER QUALITY PARAMETERS



Macroinvertebrates

Macroinvertebrates are small organisms without a backbone that are visible to the naked eye and large enough to be easily collected. Analyzing the macroinvertebrates in a waterbody can help recognize signs of ecosystem health.

Why do we measure macroinvertebrate communities?

Insects are the most common macroinvertebrates in aquatic systems, living in water as nymphs or larvae at least until they reach their adult stages. Common insects in aquatic systems include dragonflies, caddisflies, stoneflies, beetles, midges, and mayflies. Others, such as aquatic worms, leeches, and small crustaceans (crayfish and fairy shrimp), live entirely in water. Most species live in the bottom sediments of the waterbody or attached to rocks, vegetation, logs, and sticks. Lifespans range from a few weeks to several years. Macroinvertebrates are most frequently used for biological monitoring, or "biomonitoring," because of their prevalence in aquatic habitats and their differing sensitivities to chemical pollution and physical disturbances. Biomonitoring is the use of organisms to assess the overall quality of their environment or habitat. Because they generally have limited mobility and cannot escape pollution, macroinvertebrates better reflect the long-term water quality of a site compared to a single sample of chemical constituents that only provides a snapshot in time. Table 1 shows examples of generalized pollution sensitivity (tolerant or intolerant of pollution) for several common macroinvertebrates.

Table 1. Examples of macroinvertebrates and their pollution sensitivity levels.

Macroinvertebrate		Pollution Sensitivity
Stonefly		Intolerant
Mayfly		Intolerant
Crayfish		Moderately Tolerant
Leech		Tolerant
Aquatic worm		Tolerant

Source: Maine Department of Education (Nd)

Knowing the typical variety and abundance of macroinvertebrates in a healthy waterbody in a region can help indicate signs of poor ecosystem health. Generally, healthy waterbodies support a diverse population of macroinvertebrates. Samples yielding only pollution tolerant species, a low abundance of organisms, or very little diversity (primarily one or two species) might indicate a degraded waterbody. Figure 1 shows an example of a mayfly, a type of pollution sensitive macroinvertebrate.



Figure 1. The mayfly, a type of insect, under the view of a microscope. Credit: Photo courtesy of USGS

An assessment of macroinvertebrates helps to determine whether a stream's designated uses related to aquatic life are supported (protection and propagation of fish, shellfish, and wildlife). Unlike other parameters, macroinvertebrates offer a direct measurement of the condition of the biological community within a waterbody.

For factsheets on other water quality parameters, visit: epa.gov/awma/factsheets-water-quality-parameters.

For more information about the CWA Section 106 Grants Program, visit: <u>epa.gov/water-pollution-control-section-106-grants</u>.

What affects macroinvertebrate communities?

Several factors, including streamflow, geology, elevation, temperature, dissolved oxygen, seasonal life cycle patterns, substrate, and riparian habitat influence the abundance and diversity of macroinvertebrates in a waterbody. Human-induced changes to aquatic ecosystems can include increased pollution (from urban runoff and point source discharges) and land use changes that alter natural streamflow patterns, modify the channel structure, or contribute to nonpoint source loadings to the waterbody.

Below are some examples of the effects of human-induced changes on macroinvertebrate communities:

Increased turbidity and sedimentation in the waterbody from reduced riparian vegetation or other causes of erosion can eliminate food sources and habitat for macroinvertebrates. Excess nutrients can promote algal blooms. The eventual death and decomposition of the excessive algae depletes dissolved oxygen, reducing macroinvertebrate survival. Increased concentrations of metals, pesticides, or other toxic pollutants can shift the relative abundances of macroinvertebrates toward more pollution tolerant species. Altered pH affects macroinvertebrate survival by weakening shells and exoskeletons (if pH is decreased) or reducing the survival of alkaline-intolerant species (if pH is increased).

What are EPA's recommended criteria for macroinvertebrates?

There are no published EPA recommended water quality criteria for macroinvertebrates. However, guidance materials are available to help develop biological criteria that define specific characteristics of healthy macroinvertebrate, fish, or algal communities. A useful example of an approach to setting targets is EPA's *A Practitioner's Guide to the Biological Condition Gradient: A Framework to Describe Incremental Change in Aquatic Ecosystems* (2016). A multimetric index approach can be used to set targets for biological criteria. A macroinvertebrate multimetric index (MMI) is a numerical value calculated by combining individual measurements (metrics) of the macroinvertebrate community in a sample into an overall index score. This score is intended to reflect the overall condition of the macroinvertebrate community. There are often different indices and thresholds for different regions and waterbody types.

How do we measure macroinvertebrate communities?

Macroinvertebrate samples are collected in the field and identified in the laboratory (Figure 2 and Figure 3). An MMI used to characterize samples may include abundance, richness (number of species present), composition (proportions of species), number of pollution-sensitive species, or other measurements appropriate for the program's data analysis and assessment methods. There are many examples of the development and use of macroinvertebrate indices by states, tribes and other agencies including EPA's National Aquatic Resource Surveys. This work can be leveraged as ecoregional indices/MMIs to be used along with their protocols.

Sampling locations and times

Sampling locations can be selected using a targeted design or random design. For example, river or stream sampling sites may be located in riffles (shallow, turbulent sections of a river) or runs (smooth-flowing sections of a river) to represent the range of macroinvertebrate habitats. Samples are typically collected by moving upstream to prevent disturbance. Sampling times, seasons, and frequencies should be determined by the life cycles of the macroinvertebrate species as appropriate.

Macroinvertebrates



Figure 2. Using a net to collect macroinvertebrates. Credit: Photo courtesy of USEPA

Equipment and methods

Macroinvertebrate sampling requires little equipment, with methods depending on the waterbody being sampled. For example, nets (Figure 2) are typically used in streams. After sampling, samples are sorted and identification is done visually. A microscope can be connected to a screen to provide higher quality lighting and magnification (Figure 3). Unless the data are for educational purposes, it is strongly encouraged that the samples be reviewed by a trained taxonomist, which may be a staff member or an outside expert.

Other parameters measured at the same time

Macroinvertebrates are the most commonly measured organism group for biological assessments, followed by fish and periphyton (organisms such as algae that attach to objects in waterbodies). Measurements of basic water quality parameters (pH, temperature, turbidity, dissolved oxygen [DO], nutrients) taken during sampling will give a more complete picture of the overall status of the waterbody.



Figure 3. Using a microscope to identify macroinvertebrates. Credit: Photo courtesy of USGS

What are the challenges of using macroinvertebrates as a water quality parameter?

Some of the general challenges in macroinvertebrate sampling include ensuring consistency among staff when collecting samples, taking appropriate sample sizes, and conducting adequate research to understand and interpret results. Specific considerations include the following:

- Because some macroinvertebrates are small and fastmoving, adequate training is needed to collect them.
- Findings can vary based on the method used, sample size collected, and taxonomic level used. Thus, it may not be appropriate to average or otherwise combine data from multiple macroinvertebrate samples when assessing waterbody health.
- Because macroinvertebrates are affected by multiple pollutants, using them to identify or track a specific pollutant of concern is challenging. Also, macroinvertebrates do not respond to all types of pollutants. For more information, see EPA's Stressor Identification Guidance Document (2000).
- Because macroinvertebrates are affected by multiple natural factors such as temperature and streamflow, the absence or presence of certain macroinvertebrates does not necessarily indicate poor or healthy water quality. This information should be considered along with other indicators of long-term water quality characteristics.

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