What are benthic macroinvertebrates?

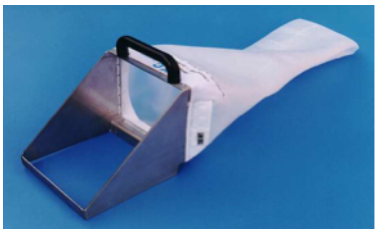
Benthic macroinvertebrates are small animals without backbones that live on or just below the stream-bed.

In most streams, the majority of benthic invertebrates are macroinvertebrates, which means they can be seen with the naked eye and range in length from 0.25 mm to 15 cm in the case of a fully grown freshwater crayfish – kōura. Most are the larvae of insects but other groups such as snails, worms and crustaceans are also common.

Benthic macroinvertebrates are sampled for assessing stream health as they play a central role in stream ecosystems feeding on periphyton (algae), macrophytes, dead leaves and wood, or on each other. In turn, adult insects leave the water and become food for birds, bats, spiders, etc. Benthic macroinvertebrates are extremely important for digesting terrestrial and aquatic organic matter and passing it on to higher levels in the food chain.

How do I sample benthic macroinvertebrates?

Two common methodologies for sampling macroinvertebrates are kick-netting (sometimes called hand-netting) and Surber sampling (see examples of sampling equipment for each of these techniques below). Which method to use depends on the reason for collecting the samples.



Example of a kick-net (left) and a Surber sampler (right).

Kick-nets are generally used when you want to know about the diversity of invertebrates or the general ecological health of a stream or river. Kick-netting is a semi-qualitative sampling technique, where the sample is not collected from a defined area of streambed. While you cannot estimate how many invertebrates were present per area streambed, you can estimate the proportions of different animals (taxa) in a sample and calculate a SQMCI score (link to the section on MCI below).

A Surber sampler is used to find out the number in a defined area of streambed, for example per square metre. This is important if you want to understand how productive a stream or river is. Invertebrate numbers (or densities) can be used to calculate a QMCI score (link to the section on QMCI below).

What else needs to be considered when sampling for benthic macroinvertebrates?

Timing

In New Zealand, the presence or absence or the amount of different invertebrate groups does not vary between seasons, so communities can be sampled at any time of the year for use of stream health indices such as EPT taxa richness and the MCI. However, to effectively compare sites and consider long-term trends, it is important to sample during the same season each year (typically summer). Invertebrates should not be sampled within 2-3 weeks following a large flood, as a lot of the animals may have been washed out.

Habitat considerations

The diversity and density of invertebrates can vary a lot within a stream. For example, there will be a greater variety and number of invertebrates in shallow, swift riffles than in deep, slow-flowing pools; and invertebrates that inhabit the slower flowing margins of a steam may be different to those in swifter areas. It is therefore important to give thought to where in the stream invertebrates are being collected from.

How to measure river or stream health using invertebrates?

Benthic invertebrate communities are widely used as indicators of stream ecosystem health because they include a wide range of species, each with relatively well-known sensitivity or tolerance to stream conditions. The most common stream health indices are taxa richness, percentage of EPT taxa and the Macroinvertebrate Community Index (MCI).

Taxa richness

Taxa richness is considered a very coarse indicator of stream health, which is measured by counting the number of different species of invertebrates present in a sample. The benthic invertebrate community typical of pristine conditions has a high variety of species or "taxa". In general, high taxa richness is considered good, although mildly impacted (nutrient-enriched) rivers can have higher taxa richness than pristine streams and rivers.

Percentage of EPT taxa

The invertebrate community is usually dominated by three orders of insects: the mayflies, stoneflies, and caddis flies. Together, these insects are known as EPT, referring to their scientific names Ephemeroptera, Plecoptera and Trichoptera, respectively. These freshwater insects are generally intolerant of pollution, so the fewer found in a sample, the poorer the stream health.

The percentage of EPT-taxa (or %EPT) is most commonly calculated by counting the total number of mayfly, stonefly and caddis fly taxa in a sample, then dividing that number by the taxa richness and multiplying by 100. This is known as the %EPT by taxa.

A high percentage of EPT taxa indicates good stream health. However, in some New Zealand streams there are naturally few mayflies, stoneflies, or caddis flies present. Ecologists need to be aware of these factors when using the %EPT to assess the ecological health of a river or stream.

Macroinvertebrate Community Index (MCI)

The MCI is based on the tolerance or sensitivity of species (taxa) to organic pollution and nutrient enrichment. For example, mayflies, stoneflies and caddis flies are sensitive to pollution, and are only abundant in clean and healthy streams, whereas worms and snails are more tolerant and can be found in polluted streams. Most benthic invertebrate taxa were assigned a tolerance value ranging from 1 (very tolerant) to 10 (very sensitive).

An invertebrate sample is typically collected from within a small section of a stream (a reach). Higher MCI scores indicate better stream conditions at the sampled site. In theory MCI values can range between 0 and 200, but in practice it is rare to find MCI values greater than 150 and only extremely polluted or sandy/muddy sites score under 50.

The MCI for a stream site is based on the presence (or absence) of invertebrates, so semi-quantitative sampling (kick-netting) is sufficient. If you want to include the actual number of individuals of each type of invertebrate found in a sample (i.e. the quantity), you need to collect quantitative data (e.g.

from Surber samples). You can calculate either the Quantitative Macroinvertebrate Community Index (QMCI) when individuals have been counted, or the Semi-quantitative Macroinvertebrate Community Index (SQMCI) when abundances have been determined using a five-point scale of coded abundance, i.e:

Rare = 1-4 individuals found, Common = 5-19 individuals
Abundant = 20-99 individuals
Very Abundant = 100-499 individuals
Very Very Abundant = 500+ individuals

The QMCI and SQMCI scores for a stream can range between <4.00 (poor water quality) to > 6.00 (excellent water quality).

Important to know

The MCI is designed specifically for stony riffle substrates in flowing water. This means that when interpreting scores some knowledge I sneeded of the types of instream habitat where the invertebrate samples were collected. For example, some streams in New Zealand naturally do not have high-scoring taxa such as mayflies, stoneflies or caddis flies, which may be due to the geology, climate, flow regime or a natural absence of riverbank vegetation. These streams may have a MCI score indicating "poor" quality (i.e. less than 80), but may not in fact be degraded. To help overcome this problem a set of different tolerance values have been developed to be used for sites with naturally silty, soft-bottom substrates. Ecologists need to be aware of these factors when using the MCI to assess the ecological health of a river or stream.

Proposed national guidelines

In the table below are the grading guidelines for each index that are used to describe the health of a stream or river:

Quality class	Description	MCI score	QMCI/SQMCI score	%EPT Taxa
Excellent	Clean water	>119	>5.99	>70
Good	Doubtful quality or possible mild pollution	100-119	5.00-5.99	51-70
Fair	Probable moderate pollution	80-99	4.00-4.99	25-50
Poor	Probable severe pollution	<80	<4.00	<25

Where do I find more information?

Chapman, Lewis and Winterbourn 2011. Guide to freshwater crustacea of New Zealand.
Stark JD 1985. A macroinvertebrate community index of water quality for stony streams. Prepared for National Water and Soil Conservation Authority. Water & Soil miscellaneous publication. 53p. p.
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Stark JD, Maxted, JR 2007. A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Enviroment. Cawthron Report No. 1166. 58
Winterbourn Gregson and Dolphin 2006. Guide to Aquatic insects of New Zealand