

# Measuring water quality

The role of Invertebrate monitoring



— *The* —  
PISCATORIAL  
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# Invertebrate monitoring as a tool for measuring water quality

The quality of the water in our rivers, lakes and seas is important to everyone and of particular interest to anglers. Several successful approaches to assessing water quality have been developed:

- **In situ monitoring**, including invertebrate monitoring and conventional biological sampling (eg for bacterial contamination)
- **In situ water quality sensors**
- **Environmental DNA analysis**, eg to measure bacterial contamination as well as the presence of insects, plants and vertebrates such as invasive species
- **Remote sensing** (eg satellite imaging)
- **Modelling** (eg predictive hydrological models) (Humbert, Kuehne et al. 2023)

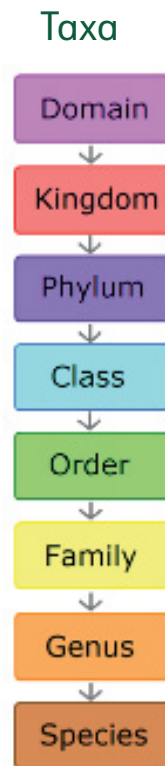
Of these, invertebrate monitoring has become

one of the most important tools and is used worldwide. In Europe and by the UK's Environment Agencies (UKEAs) it is used to measure adherence to the Water Framework Directive (WFD), whose evaluation of river health combines:

- **invertebrate biological monitoring**
- **hydro-morphological measurements** (flow, connectivity to flood plains, connection to ground water, substrate)
- **physicochemical measurements** (eg temperature, pH, nitrogen, phosphorous). (Humbert, Kuehne et al. 2023)

Macroinvertebrates are animals without a spine that can be seen with the naked eye (generally bigger than 0.5 mm) such as freshwater shrimp (*Gammarus* spp.) and mayflies (*Ephemeroptera* spp.) Microinvertebrates are tiny complex organisms such as water fleas (*Cladospira* spp.).

## Macroinvertebrate monitoring – background and implementation



A large body of scientific work since the late 1970's has identified those macroinvertebrate taxa that are "sensitive" to five major water quality indicators. "Sensitivity" refers to changes in the abundance and diversity of the affected taxa.

The abundance and diversity values for these invertebrates, as established from a reproducible sampling technique, are then used to calculate indices for 5 water quality parameters: Chemical; Siltation; Total reactive phosphorous; Organic enrichment and Flow (see below). (Murray-Bligh and Griffiths 2022).

## Independent water monitoring in UK

This is carried out both by the UKEAs for WFD compliance and by two citizen science networks, the Riverfly partnership and SmartRivers networks, which aim to fill and complement UKEA monitoring gaps.

All use the same techniques but with different levels of precision determined by the degree to which the invertebrates in a sample are classified:

- **The UKEAs** assess 106 taxa for its WFD assessment to family level – a relatively coarse measure for monitoring invertebrate-rich chalk stream communities in which abundance can be high (suggesting zero impact from poor water quality), whereas the more subtle indicator of species diversity has fallen showing a pollution effect.

- **The Riverfly Partnership's Extended Scheme** is an expanded version of the Riverfly Monitoring Initiative (RMI), limited to 33 taxa that can be identified by trained citizen scientists. This is useful, but it's a less sensitive measure than that used for the WFD or by SmartRivers. It is used to alert the environment agencies to pollution incidents and trends.

**In 2024 the partnership sampled 104 catchments.**

- **SmartRivers** – the WildFish project – undertakes a full invertebrate community survey with all samples being identified to species level if practicable (some groups like true flies are left at the family level).

This scheme provides a full assessment of both diversity and abundance which requires professional analysis. It permits a full evaluation of all five water quality measures (see next section) providing both the indices needed for a WFD assessment together with a more sensitive pollution analysis at species level. **In 2024 122 rivers were sampled by the network.**

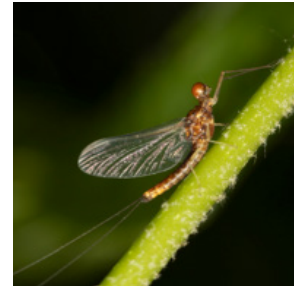
To put these analyses in context, the Autumn 2024 Wiltshire Avon SmartRivers dataset included 144 separate taxa as opposed to the 59 of these that would have been listed by a WFD dataset and the 25 in the extended Riverfly partnership dataset.

# How the data are used to calculate each of the five water quality parameters

## Chemical

Chemical measures the effect of unidentified chemical pollution. The species known to be sensitive to pesticides are termed the **SPE**cies **A**t **R**isk from pesticides – **SPEAR**. These are largely but not exclusively the **E**phemeroptera or upwings, **P**lecoptera or stoneflies and **T**ricoptera or caddis flies/ sedges, referred to as the **EPT** species.

Both the abundance and diversity of these species are reduced by chemical pollution. The values for both from each sample are then used, in a relatively complex calculation, to provide an index representing the percentage of the total sample made up of these invertebrates.



***Blue winged olive spinner and nymph***

*Order: Ephemeroptera  
Family: Ephemerellidae  
Species: Seratella ignita*

## Siltation

Sediment naturally moves into rivers through erosion, but unnaturally high levels may follow human activity including agriculture and industry. Toxic chemicals can bind to sediments, increasing their concentrations. This is measured by a reduction in the abundance and diversity of the **P**roportion of **S**ediment-sensitive **I**nvertebrates, abbreviated to **PSI** which include both the **EPT** species as well as damselflies and dragonflies (Order Odonata). The index is calculated from the sum of the abundance scores for the sensitive invertebrates as a percentage of abundance for all taxa.

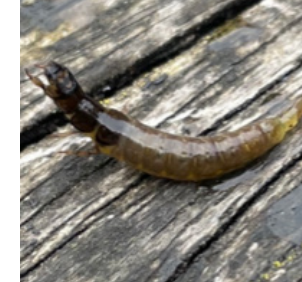


***Banded demoiselle adult and nymph***

*Order: Odonata  
Family: Calopterygidae  
Species: Calopteryx splendens*

## Phosphorous

Phosphorous is the main cause of eutrophication (over-nutrition) that leads to choking algal growth reducing dissolved oxygen and sometimes producing toxins. This measure is termed the **Total Reactive Phosphorus Index** (the **TRPI**) including those whose abundance and diversity are reduced by over-nutrition including the EPT species and Gammarus. The score is a percentage derived from the numbers and abundances of sensitive family groups divided by those for all groups.



### Caseless caddis/ sedge species

*Order: Tricoptera*  
*Family: Hydropsychidae*  
*Species: Hydropsyche pellucidula*

## Organic enrichment

This comes from wastewater and farm runoff leading to oxygen depletion as these are broken down by bacteria. It is measured by the **Saprobic index**. Saprobies are organisms that feed on, or tolerate, putrescible organic matter. The index relates directly to the biochemical oxygen demand (BOD) required to break down this material.

Different invertebrates are given a weighting based on their relationship to BOD and include some water snails, mussels, annelid worms, midge larvae and leeches. The index is derived from values for the presence and abundance of these indicator species, adjusted by weighting, as a percentage of the whole sample.



### River Nerite

*Phylum: Mollusca*  
*Family: Neritidae*  
*Species: Theodoxus fluviatilis*

## Flow

Is measured by the **Lotic Invertebrate Flow Evaluation** (the **LIFE** index). Lotic is a term describing invertebrates that live in flowing water. Flow dictates water quality – important as, when flow is reduced, pollutants are less diluted and sediments with organic matter can settle more easily. Flow is affected by, for example, abstraction, dams & weirs. The EPT species and Gammarus are reduced in abundance and diversity in low flow environments.



### Freshwater shrimp

*Order: Amphipod*  
*Family: Gammaridae*  
*Species: Gammarus pulex*

Each species or family is assigned to one of six flow categories according to their association with different flow conditions. The index is expressed as an average of the flow score for each taxon.

These data are also used to provide two overall indicators of river health:

- **The Biological Monitoring Working Party (BWMP) index.** Each invertebrate family (as opposed to any other level of taxon such as species) in a sample is given a score of 1-10 depending on their tolerance to pollution (10 = sensitive and 1 = tolerant). These values are summed to give a total score. The BWMP index has been largely replaced by the more recently validated **WHPT index**.

- **The Walley Hawkes Paisley Trigg (WHPT) index** has been used by the EA since 2017 as a

tool for measuring compliance with the WFD. Unlike BWMP, the WHPT includes abundance, together with presence or absence, to provide a score. It measures 106 taxa but does not include classification below the family level.

## Sampling technique

This uses the River Invertebrate Production and Classification Scheme (RIVPACS) sampling technique in which representative sites are repeatedly sampled using standardised equipment and standardised techniques.

Sites are sampled two or three times per year (spring, summer and autumn, or spring and autumn) to account for seasonal variations in both invertebrate populations and the pressures on them (for example, there is often less flow in autumn so pollutant concentration can be higher).

Locations to be sampled are identified on a map, or by GPS.:

- In a narrow stream the sampling area should be within seven channel widths upstream or downstream of the location.

- In a wide stream a recommended 50m up or downstream of the location although ideally as close as possible to maintain the same microhabitat types.
- The substrate type is recorded, and flow estimated on each occasion.

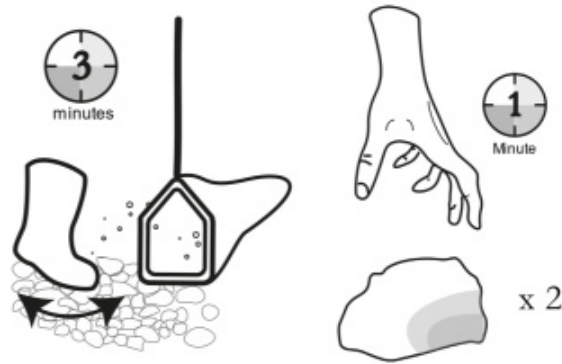
Three techniques are used depending on the water depth:

1. Up to 0.8m (averaged across three depth measurements  $\frac{1}{4}$ ,  $\frac{1}{2}$  and  $\frac{3}{4}$  of the width): three-minute kick-sample and one-minute manual search split proportionally to include all the different habitats in the location.

2. Deeper water < 15m wide: one-minute manual search, one-minute marginal sweep and three minutes sampling with a long-handled pond-net similarly split between habitats as above.

3. Large deep rivers: one-minute manual search, one-minute marginal sweep and then using an airlift technique (suction pump) from a boat.

The Piscatorial Society rivers are shallow enough for the kick sampling technique. At the kick-sampling location the operator starts downstream and works upstream dividing the time (three minutes kick and one minute



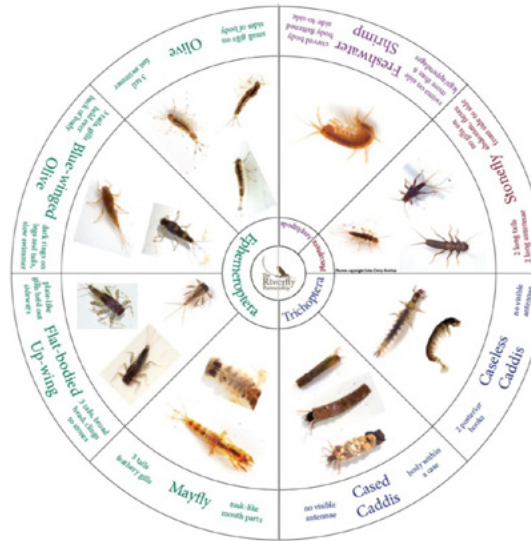
Watch video from the WildFish SmartRivers team

manual search that wipes invertebrates off rocks into the net) between the different micro-habitats at the site.

In addition to kicking up the riverbed to release invertebrates living there the net is used to sweep into river plants to sample invertebrates living there.

If surveying multiple sites along a river, the best practice is also to start at the lowest site and move upstream, unless there are biosecurity considerations such as Signal crayfish at lower sites that are not present upstream and which should not be transferred there.

Samples are then either assessed by citizen scientists using identification charts like the ones available from the Riverfly partnership or sent to a professional laboratory:



SmartRivers samples are sent to the Aquascience Consultancy, for speciation and reporting (costs about £250 for a sample)

The Piscatorial Society has carried out its monitoring through the WildFish SmartRivers network since 2019 with twice-yearly sampling by our Keeper team. We receive biennial reports from WildFish for our locations as well as for the others within the same catchment for comparison. Longitudinal trends for the last 5 years are becoming available.

## Understanding the results

We have produced a detailed explanation of how to read a SmartRivers report – available in the Society’s online library in the Environment > Monitoring & Surveys folder.



**Professor John Dart**

Originally a marine zoologist, John then trained as a physician and continues to work as a clinical scientist at Moorfields Eye Hospital and UCL, as Hon Consultant and Professor.

He is the Secretary of the Grayling Research Trust, and since 2014 has been responsible for developing and overseeing the research base for the Piscatorial Society’s fisheries, including the Wylde grayling study, the effects of the River Anton restoration and the impact of Beaver colonisation on bankside structure, vegetation, hydrology and fish movement.