Biological water quality monitoring

in the Midlands Region

ENVIRONMENT AGENCY

Protecting the environment

The Environment Agency's main aim, as set out by the Environment Act 1995, is to protect and enhance the environment and to help achieve sustainable development. To do this, the Agency must take an integrated approach, considering the impact of substances and activities on all environments and natural resources.

The Agency has specific duties to gather information so that it can assess the general state of the environment and take measures to control pollution. It also has a duty under the Water Resources Act 1991 to monitor the extent of pollution to controlled waters. Biological monitoring of the aquatic environment is an integral part of these duties.

Most commonly, biological monitoring detects changes in the population structures of living organisms that occur when an ecosystem is subjected to pollution or other types of environmental stress.

Organisms used in biological monitoring

Biologists in the Midlands Region typically carry out surveys involving sensitive indicator species of both animals and plants to assess changes to their environment.

Animals (macroinvertebrates)

Macroinvertebrates are the small animals found in rivers, which are visible to the naked eye. These include insect larvae such as mayflies, damselflies and caddis flies together with snails, shrimps and worms. These animals tell us about the environmental quality of rivers. They are unable to move very far and respond to everything contained in the water. This includes pollutants that occur only infrequently or at very low levels and which can be easily missed by chemical sampling.

There are three common ways in which pollution affects macroinvertebrates:-

- **toxic pollutants** (eg. metals in acid mine drainage) which are poisonous and kill the animals directly.
- **organic pollutants** (eg. sewage and slurry) which although not always poisonous themselves, kill invertebrates indirectly because they cause the proliferation of microbes like bacteria and fungi that feed on these substances. These microbes use up the oxygen in the water, as they degrade the organic material, so that the level becomes too low for many invertebrate species to survive.
- **physical problems**, the most common of which are fine particles in suspension (eg. dredging silts), which even if inert, can kill animals by smothering their habitat or by blocking their gills.

Combinations of these three effects are common, for example sewage effluent is mainly organic matter, but it contains ammonia which is toxic, and fine particles which cause siltation. Detergents and oils cause damage because of their physical and toxic effects.

Different groups of animals vary in their tolerance to pollution. Each species thrives best under a different range of environmental conditions, and knowledge about this is used to assess the conditions in a river. For example, most mayflies and stoneflies need well oxygenated water, whilst blood worms can thrive where there is very little oxygen. By using this knowledge and carrying out regular checks on the macro-invertebrates, the Environment Agency can monitor the overall condition and health of our rivers.

Sampling

The standard sampling methods used by the Environment Agency have been developed in collaboration with the Institute of Freshwater Ecology (IFE), (now the Centre for Ecology and Hydrology CEH). These methods ensure that all data, and the information derived from it, are comparable and of good quality.

For monitoring overall ecological quality, we select sites which are typical of the stretch of river being assessed. Each sample will include animals collected from all the different habitats at the site, such as areas of gravel, silt and different types of weed beds. In shallow water, we use a pond-net, while in deeper water a dredge is more suitable. Samples are often collected in more than one season, so that we can take account of seasonal variations when analysing the results. We follow standard procedures to assure the quality of the data; these are supported by training and internal analytical quality control (AQC) and independent external audits.

The BMWP score system

This system was devised by the Biological Monitoring Working Party (BMWP) for the 1980 Water Quality Survey of England and Wales. It is widely accepted as a simple means of assessing biological quality.

A number is allocated to each invertebrate taxon (taxon, plural taxa, are terms which cover animals identified to species, family or any other required level), based on its tolerance to organic pollution, from one (tolerant) to ten (sensitive). For example, most mayfly and caddis larvae score ten, water beetles five, snails three, and worms one. Summing the values for each taxon found in the sample gives the BMWP score for a site. The Average Score Per Taxon (ASPT) is an index of organic pollution. It is the BMWP score divided by the number of scoring taxa (macroinvertebrate taxa used to determine the BMWP score) in the sample, and represents the average sensitivity of the taxa found. It is more reliable than other biological indices because it is less affected by sampling effort and the presence or absence of a few rare taxa, (sometimes caused by habitat disturbance).

The number of scoring taxa is used as a general index of pollution, including organic, toxic, and physical pollution, such as siltation. A large number of taxa indicates a rich community and a healthy environment; a low number may indicate pollution.

We use these indices to detect and evaluate changes in river quality at monitoring sites, as well as differences between similar sites on the same stretch of river. We could use these indices to determine whether an effluent discharge or pollution has a detrimental effect by comparing conditions upstream and downstream from it.

RIVPACS

Some types of river support a richer invertebrate community than others because of natural differences such as the nature of the stream bed or flow regime. So the BMWP-scores and numbers of taxa in samples from different sites can differ widely, irrespective of water quality. The Environment Agency uses the computer programme RIVPACS (River Invertebrate Prediction And Classification System) developed by the IFE to take account of these natural differences, so that we can compare all sites in terms of their biological quality.

RIVPACS has been developed over the last twenty years. Computer analysis was used to classify the macro-invertebrate communities associated with different river types. This was based on surveys of the macro-invertebrate species and environmental characteristics at 614 reference sites with limited human impact throughout Britain and 70 in Northern Ireland. RIVPACS III for Britain can be purchased from the Institute of Hydrology. From a site's physical and chemical characteristics, RIVPACS can predict the BMWP-score, ASPT and number of taxa that a standard sample would have if the river was unpolluted and undisturbed. The difference between the reference value of an index predicted by RIVPACS and the value derived from a standard sample indicates the impact caused by pollution or habitat degradation. These differences are expressed as the observed value divided by the predicted value, and are known as Environmental Quality Indices (EQIs).

If the EQI is approximately equal to or greater than one (i.e. the observed value matches or exceeds the predicted value), the biological quality is deemed to be very good. As the value drops below one, it indicates progressively poorer biological quality.

Plants

Macrophytes are water or marsh plants that are visible to the naked eye, including macroscopic algae such stoneworts and blanketweed. Macrophytes can be submerged, emergent or floating and either rooted in the sediment or free floating. They are useful for pollution monitoring, complementing the information derived from macroinvertebrate surveys.

Aquatic macrophyte monitoring

Macrophyte surveys provide visible evidence of 'undesirable disturbances' to the ecosystem, because plants respond more directly to inorganic nutrients than macro-invertebrates; different plant species vary in their preferences for nutrients from both water and sediment and reflect the quality of the whole river system; free floating plants respond directly to water nutrient levels.

Eutrophication is the enrichment of waters by inorganic plant nutrients usually compounds of phosphorous and nitrogen, causing an accelerated growth of algae and higher forms of plant life which disturbs the balance of the ecosystem or the quality of water.

Eutrophication increases overall plant cover and reduces diversity as the community becomes dominated by one or a few species that can tolerate high nutrient concentrations. There will usually be an increase in the proportion of filamentous algae, which respond rapidly to water nutrient levels. These changes may also affect amenity value and cause problems for abstractors or other water users.

Changes in the trophic status of a river can be quantified using the Mean Trophic Rank (MTR). This is a methodology that has been developed to express the impact of eutrophication in terms of a biotic score based on the aquatic plant community. Each macrophyte species has been allocated a Species Trophic Rank (STR) scores ranging from one to ten. High scoring plants are associated with waterbodies that are low in nutrients. Low scoring plants are either tolerant of eutrophication or have no preference in their nutrient requirements. The MTR score is calculated from the STR and abundance (estimated cover classes) of each species present in a 100m stretch of river. It ranges from a theoretical maximum of ten, with higher scores indicating lower levels of eutrophication. In practice, at any site, the maximum attainable MTR is restricted by floristic diversity and physical parameters such as flow regime, river size, geology and water chemistry.

Using the information provided by the study of macroinvertebrates and macrophytes, we can detect environmental changes in rivers and watercourses, detect pollution and identify where environmental management is improving the overall river ecology.

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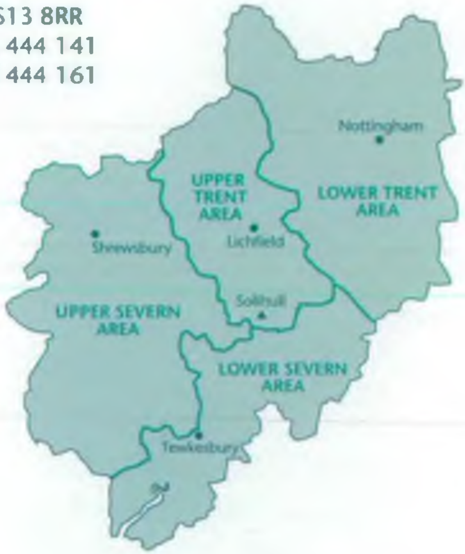

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