

An Introduction to Aquatic Biological Monitoring

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Biological monitoring (biomonitoring) is the use of living organisms as a tool to assess the condition of the environment. Recently, a method for assessing water quality from the invertebrates living in streams was devised, called 'rapid assessment' (Wright *et al*, 1993). In the case of a stream, this works on the simple principle that some organisms living in a stream are more sensitive to pollution than others. When animals caught from a test site are identified, two main factors will indicate if it is unpolluted. Firstly, there should be a large variety of animals, secondly, a sample should include species which are characteristically sensitive to pollution (Fig. 1). The results of a collection can be compared to other streams called reference sites which have similar physical conditions, but are known to be unpolluted.

History

The change in aquatic life as a response to pollution is by no means a novel concept. Effects of sewage discharges on the flora and fauna downstream of towns have been studied since the turn of the century (Chapman, 1996).

The first practical application of water quality assessment using the biota was known as the 'saprobic system' devised by Kolkwitz and Marson in 1902 (Chapman, 1996). This system, which was mainly used in Central Europe, characterized zones of pollution by the colour and smell of the water, as well as the biological organisms found at a sampling site.

In South Africa, Arthur Harrison presented a paper entitled "The role of river fauna in the assessment of pollution" at the 'Conseil Scientifique pour l'Afrique au sud du Sahara' specialist meeting on water treatment in Pretoria in 1960 (Harrison, 1960). His initial work still has relevance today. He noted that faunal data would be useful:

- when episodes of intermittent pollution (which would not always show in chemical tests) were suspected,
- where the pollutant was undetectable by chemical tests, and,
- where the environmental impact was not toxic in nature.

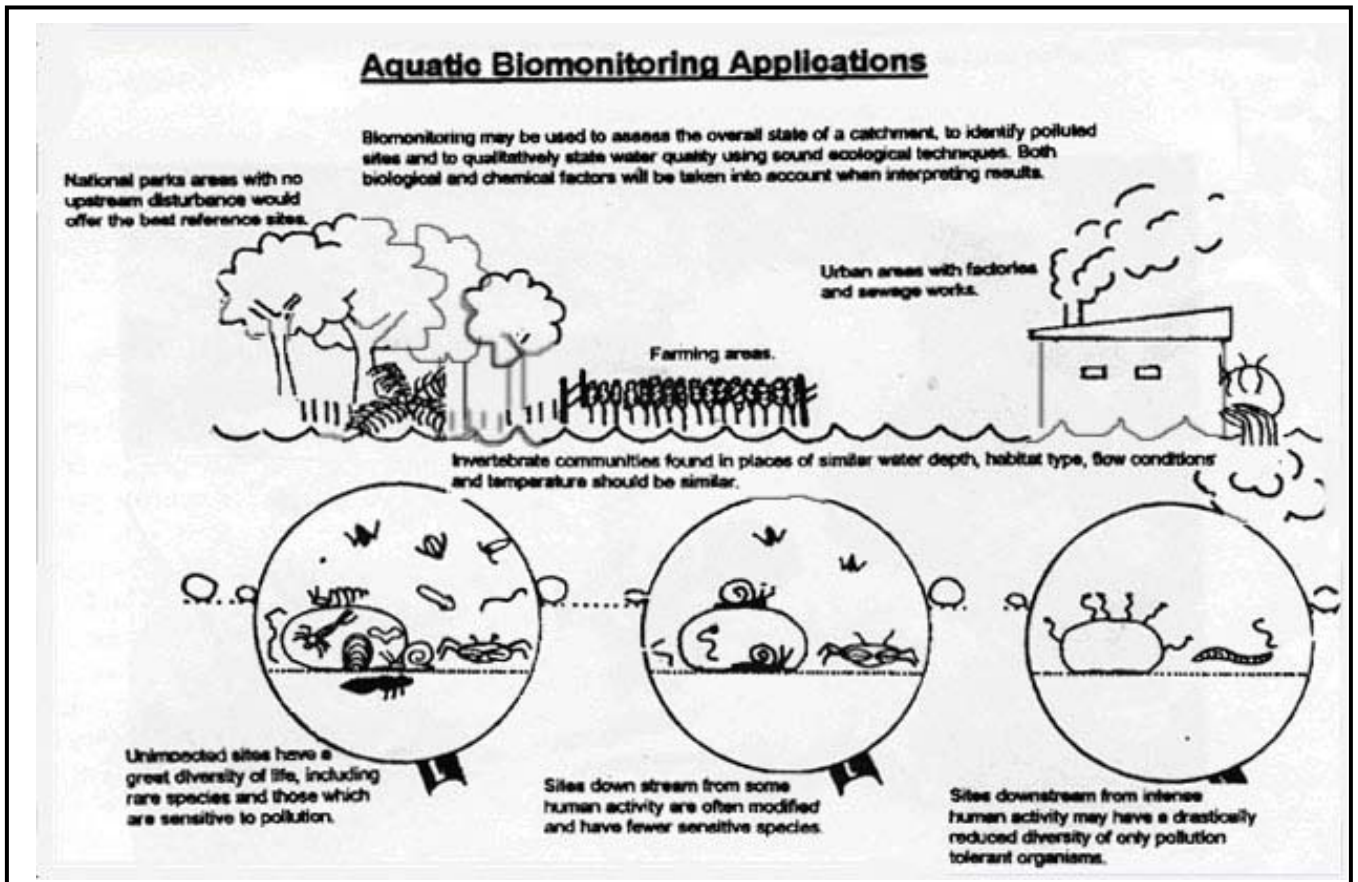


Figure 1. Basic applications and principles of aquatic biomonitoring

The use of many plant and animal groups provided thorough but time-consuming ecological assessments of pollution episodes including organic matter, silt and acid pollution (Harrison, 1960) but interpretation of these data required specialist knowledge.

As the study of ecology evolved, community structure became more important and a host of indices became available, which could be used to assess aquatic pollution (Chapman, 1996). Many were designed for specific programmes and remained fairly obscure, while others such as the Shannon and Wiener index or the Simpson diversity index have become commonplace in current research. These indices involve calculations which can be difficult for a non-specialist to use and understand. There is clearly a role available in water quality research for a simple index which can be easily calculated and understood so that water managers having minimal biological training can use it with ease. However, this index must be backed by firm ecological principles.

In the late 1970s, the Biological Monitoring Working Party (BMWP) in UK developed a scoring system based on family-level identifications for rapid aquatic site appraisals (Wright *et al.*, 1993). This was based on the tolerance of aquatic invertebrates to organic pollution and an Average Score Per Taxon (ASPT) could be calculated (Wright *et al.*, 1993). Eventually, the programme became refined to species level identifications and a computer based prediction scheme evolved, known as **RIVPACS** (River and InVertebrate Prediction And Classification System). The basic scores from the BMWP were adapted to South African conditions by Dr F.M. Chutter and after much testing, the South African Scoring System version 4 (**SASS4**) was produced (Thirion *et al.*, 1995).

How does it work?

The invertebrates should ideally be collected from perennial rivers where there is an abundance of stones in the current habitat (Thirion *et al.*, 1995). This is a very productive biotope because it is more stable than sand and offers a greater surface area for attachment of periphyton than boulders. There are also many places for organisms to hide. The stones in current biotope are invariably abundant at small rapids, termed riffles. It is also important to make sure that all other habitats present at the site are sampled; these may include aquatic vegetation, sand, mud and stones out-of-current (Dallas, 1997).

Collections of the invertebrates are made using a standardized net. The collector moves upstream pushing and rubbing stones with his feet, attempting to disturb the substrate to a depth of about 10 cm, the net being held just downstream, to catch animals carried away by the current (Fig. 2) (Chutter, 1995; Murray-Bligh *et al.*, 1997). Sampling usually takes about three minutes, and this is in a series of short, thirty second bursts. The invertebrates are then tipped into a shallow tray where they are separated from debris and identified down to family level. The presence or absence of a family (Fig. 3) is noted on the SASS sheet which has sensitivity ratings on it. When the score of each family present is added up, it gives a total which is called the **Sample Score** (Chutter, 1995). When this is divided by the number of families present, an average score per taxon (ASPT) is given (Chutter, 1995). The ASPT is, therefore, a measure of the average sensitivity of all the organisms present to organic pollution.



Figure 2: Collection of macroinvertebrates in the Mazowe Catchment

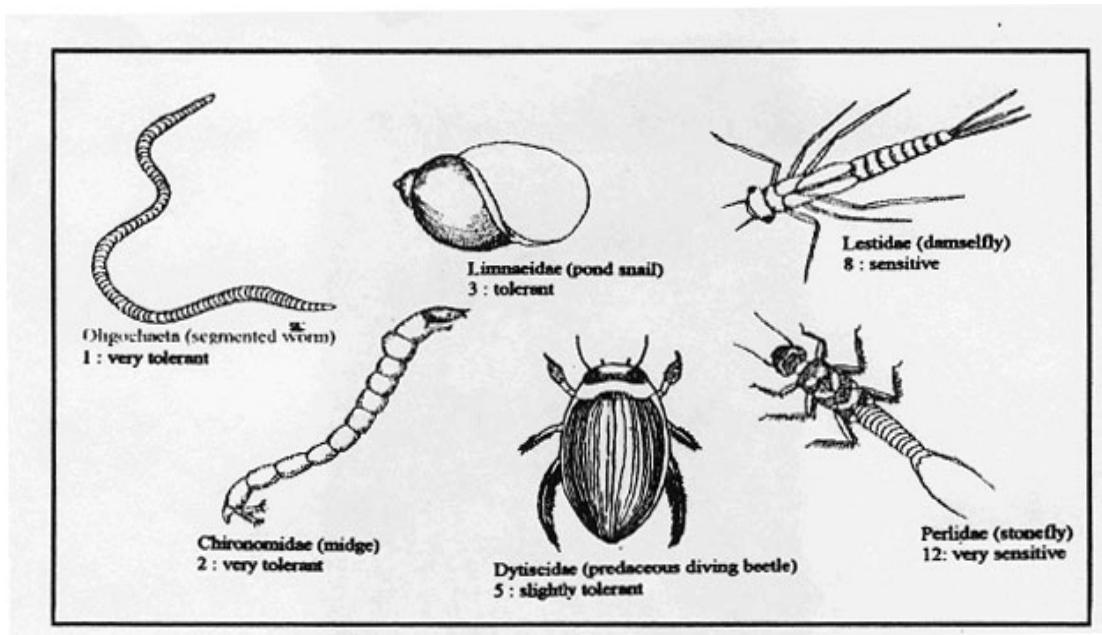


Figure 3. Some common invertebrate taxa and their SASS sensitivity ratings

An ASPT of above 7 indicates very good water quality, an ASPT of less than 3 indicates poor water quality (Thirion *et al.*, 1995). The assemblage of organisms present may help to identify the nature of the pollution. Sites with high numbers of annelids and chironomids are often organically polluted (Thirion *et al.*, 1995). If the ASPT is high, but there are only a few families present (low diversity), the site may have been polluted by an inorganic substance such as acid (Thirion *et al.*, 1995).

Why use rapid assessment biological monitoring? Rapid assessment is very simple compared to other biotic indices of water quality, most of which have found little practical application. Chutter (1995) suggests that the other indices have not been successful because the people who develop the indices are not always the people who have had to use them. The advantages of the rapid assessment approach outlined by Chessman (1995) are:

- invertebrates form key links in the food chain and are abundant in all healthy rivers;
- they are a convenient size for collection and storage;
- identification need only be made to family level which avoids nomenclature problems in the absence of good taxonomic keys;
- equipment requirements are simple and inexpensive making it a sensible, appropriate technology to use in developing countries.

The sheer elegance and simplicity of this monitoring technique improves effective communication amongst all interested parties. Traditionally, chemical tests are used to detect any problems with water quality. Unfortunately, it is difficult to tell what ecological effects any particular effluent will have on the teeming life found in a healthy

stream. Each separate contaminant must be tested for individually and this can be prohibitively expensive if one is not sure what to look for.

Compared to the traditional chemical monitoring methods, biological monitoring is less precise, as it cannot determine the exact nature of the pollution. But it is sensitive and is especially useful in detecting manmade disturbances other than chemical pollution (Norris and Norris, 1995). Rapid assessment can even detect episodes of intermittent pollution because the biota contain the only clues as to what has occurred, long after the polluted water has been washed downstream and diluted (Norris and Norris, 1995).

Aquatic biomonitoring in Mazowe Catchment

The Mazowe Valley Catchment Development programme was faced with the challenge of determining the state of the rivers in the Catchment, at the beginning of 1997. Biomonitoring was chosen as it was the most sensitive, user-friendly, method and gave the best information returns for investment. The technique has since been widely used in the upper catchment (Gratwicke, 1998). Extensive areas of the upper catchment were found to be degraded, with very few sites being pristine enough to act as reference sites. However, despite these problems, the method was found to be a sensitive one when successfully applied and has a lot of potential for use in the Zimbabwean context.

The importance of maintaining healthy river systems

Rivers are essential to everyone and their health should be of prime concern to all water users. In order for a river to "self-purify" it needs to be in a healthy state to

absorb the impact of chemical cocktails and organic matter which continuously bombard it. Areas where direct river bank degradation occurs by activities such as river bank cultivation, goldpanning, and breaching of dams, are often the poorest in terms of ability to self purify. Healthy riverine ecosystems are not only essential in terms of maintaining good water quality, but are needed to preserve rare or sensitive species which contribute to the health of the food web and the overall biological diversity of the area.

Some negative impacts resulting from deteriorated water quality are:

- reduced self-purification ability of the stream (as food chains are shortened, the buffering capacity of the stream is lost).
- reduced aesthetic qualities, making the water unsuitable for recreation or tourism.
- disease outbreaks. Eutrophication problems in Lake Chivero and subsequent blooms of toxinproducing cyanobacteria may be linked to seasonal outbreaks of gastroenteritis (Marshall, 1997).
- fish deaths. In March 1996, massive fish deaths were witnessed in Lake Chivero, due to a situation created by eutrophication of the lake (Moyo, 1997).
- blooms of water hyacinth. These weeds have undesirable ecological effects and also increase evapotranspiration losses from a water body. (Mpofu, 1997).
- increased costs of water purification for drinking purposes. Foul smells and taste from cyanobacteria associated with pollution, decrease consumer satisfaction with drinking water (Carmichael, 1994).

Conclusion

It has been found that rapid assessment biological monitoring offers a simple, cost-effective means of assessing water quality. It can provide site-specific results, which can be resolved in considerable detail, and this can be used as an environmental assessment exercise. Through long-term programmes, solutions to existing problem areas can be individually tailored and subsequently monitored.

It is imperative that such a promising, new, appropriate technology is fully disseminated so that it can meet the information requirements of water users around the country. In this way, a truly sustainable means of water quality management can be realized which will complement other water quantity management options already in place.

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