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A comparison of two methods for biological water quality assesssment in Dutch streams

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Introduction

Since 1980 the Limburg Water Pollution Control Authority (LWPCA) has investigated the applicability of several methods for biological assessment of the water quality in running waters. Aims and early results of these studies were published by TOLKAMP (1984, 1985).

In the present study the saprobic-index (SLÁDEČEK 1973), as one of these methods is compared with the latest draft of the German standard method (DIN, 1988). The saprobic-index used by the LWPCA (Sh) is normally calculated using an indicator species list adapted to regional conditions by the selection of 115 macroinvertebrate species frequently found in the region. This species list is identical to the one used by our German neighbours (LWA-NW, 1982), with this difference that much more species are included in the Sh. As was the case in the LWA-NW-list, the saprobic values of the added macroinvertebrates were derived from SLÁDEČEK (1973) and MAUCH (1976).

The DIN draft prescribes a saprobic system using the existing formula to calculate the saprobic-index (Sh-DIN) but the indicator species list contains some other taxa and different saprobic values and weights per taxon. The macroorganisms of the Sh-DIN other than macroinvertebrates (e.g. Porifera and Pisces) were not considered in the present study and all calculations were carried out with the remaining 155 macroinvertebrate species.

Both the Sh and the Sh-DIN are calculated on the basis of abundances, reducing the actual numbers of specimens to seven classes (MOLLER PILLOT 1971). The DIN-draft prescribes a statistical test to verify the reliability of the calculated saprobic index. The standard deviation of the saprobic index of a sample should be less than 0.2 and the sum of the abundances should exceed 14.

Study area and methods

The data used in this study were collected in the province of Limburg (The Netherlands) in 1987, where 165 samples were taken in the various stream types present in this region. Samples were taken in 55 streams in spring and autumn and in another 55 streams only in spring. All samples were taken with the standard handnet (30 cm wide and 50 cm deep with 0.5 mm mesh size) which was used in upstream direction for kick-sampling (5 areas of 0.5 m length) or push-sampling through the top layer of softer bottoms (a total length of 5 m). In areas where both methods failed a sample was taken by collecting substratum (e.g. stones and branches) by hand. When possible a combination of two or three methods was used.

Macroinvertebrates were collected quantitatively except for very numerous taxa, of which a considerable portion was collected to ensure that all species were included, while total numbers were estimated by counting only a portion of the sample. All animals were stored in 80% alcohol and identified to species level using the latest identification keys, except for flatworms which were identified alive. This semi-quantitative method differs from the more qualitative method used by the LWA-NW, where abundances are estimated in the field and only a few animals, which cannot be identified *in situ*, are collected for further identification. The latter method might cause a loss of species and appears to lead to overestimation of the abundances.

Results and discussion

The species listed for the Sh are indicative for the (foot)hill streams and lowland streams in Limburg. For the Sh-DIN the species used are found in springs, mountain streams, (foot)hill streams and lowland streams. Compared with the selected species of the Sh, a difference can be seen between the organisms listed and the values per taxon. The weight scale, which indicates the reliability of a saprobic value per taxon, has changed from 1–5 (Sh) to 1–16 (Sh-DIN). In the Sh-DIN list species of the Sh-list with saprobic values below 2.0 are partly absent and for the remaining species most of the saprobic values were higher. New species with low saprobic values were added to compensate for this feature, but those species, e.g. flat stonefly larvae and flat mayfly nymphs, are more indicative for springs, mountain streams and hill streams and are rarely found in foothill streams or lowland streams. Both the Sh and the Sh-DIN contain only few species with saprobic values above 3.0. Al-

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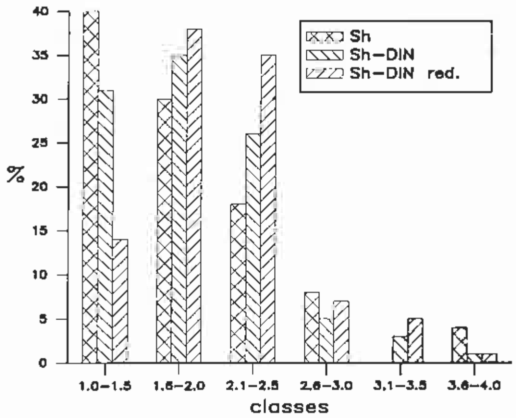

Fig. 1. Frequency distribution over 6 classes for the saprobic values of the indicator organisms listed in the Sh, Sh-DIN and Sh-DIN-red.

though most of these species are alike for both methods, the saprobic values are different again. In this case the Sh-DIN uses lower saprobic values than the Sh.

Since the Sh-DIN contains many species not occurring in Limburg the original list of 155 macroinvertebrate species was reduced to 85 species (Sh-DIN-red.). In Fig. 1 the frequency distribution over six classes of the saprobic values is shown for the saprobic indices and it is clearly demonstrated that there is no equal distribution over the classes for the Sh, the Sh-DIN and the Sh-DIN-red. Finding more species in classes with a low saprobic index is easily explained by the fact that a better water quality in general means a higher species diversity. Apart from this distribution pattern one has to consider the chance to find organisms with specific saprobic values. In case of the Sh-DIN, applied to the Limburg situation, only a few species

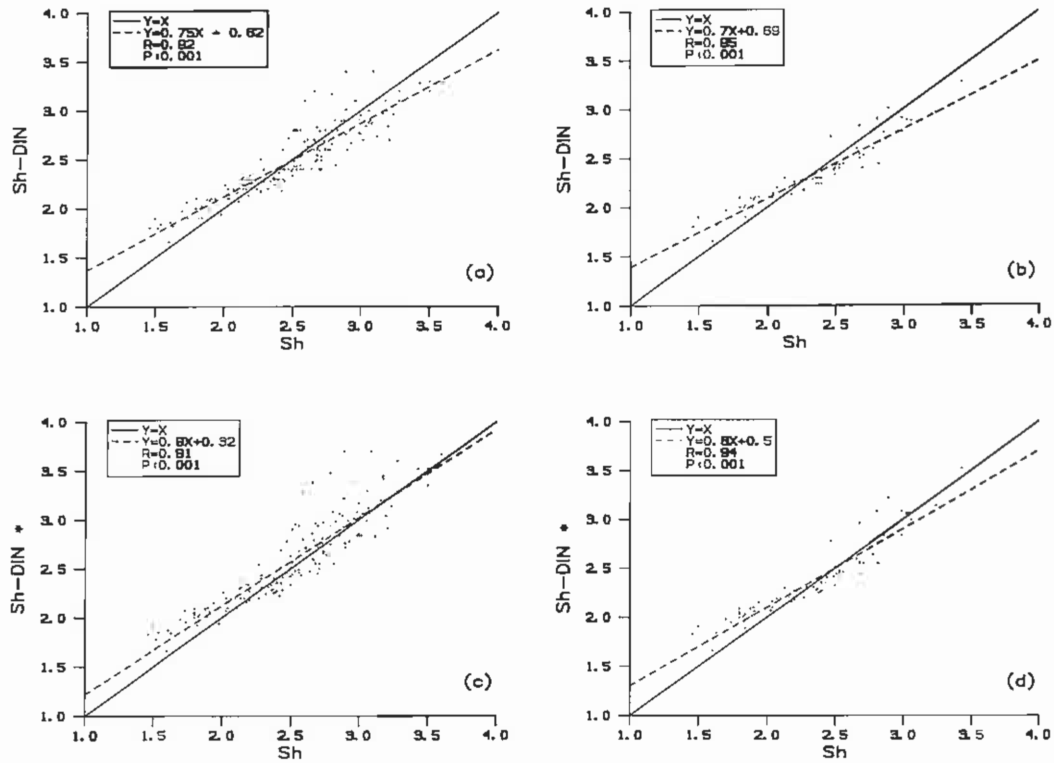

Fig. 2. The relationship between the Sh and the Sh-DIN for 165 samples; a) no correction for the standard deviation and the abundance has been made and b) after correction for Sh-DIN; c) with changed values of *Chironomus thummi* and Tubificidae for the Sh-DIN (Sh-DIN*), no correction and d) with changed values, after correction.

Table 1. Percentages of samples (N = 165) included in the calculation of the Sh and the Sh-DIN under varying conditions. SD = Standard Deviation; Ab = cumulative Abundance; Correct = samples meet the statistical demands.

Sh				Sh-DIN			
SD > 0.2 (%)	Ab < 15 (%)	SD > 0.2 Ab < 15 (%)	Correct (%)	SD > 0.2 (%)	Ab < 15 (%)	SD > 0.2 Ab < 15 (%)	Correct (%)
48	4	13	36	13	19	25	42

with low saprobic values will be found because of the geographical distribution of these species. On the other hand, although the saprobic reach from 3.0 to 4.0 is only represented by a few species, these species are very common and often found in large quantities. The use of abundances partly corrects for the fact that some species, although very indicative, are never found in large quantities (e.g. caddis fly larvae), while other species can be very abundant (e.g. non biting midges) and can strongly influence the saprobic index.

The relationship between the Sh and the Sh-DIN before and after correction for the standard deviation and abundance is illustrated in Figs. 2 a and 2 b, respectively. This correction was only made for the Sh-DIN, omitting samples that did not meet the requirements. Following the same procedure for Sh (as in Table 1) would lead to such a severe reduction of the data set that not enough data would remain. The conclusion can be drawn that the saprobic values of the samples obtained with the Sh-DIN are restricted to a smaller reach of the saprobic spectrum (1.7 – 3.4) than the values of the Sh (1.4 – 3.6). Samples with low saprobic values are underestimated (Sh-DIN higher) and samples with high saprobic values are overestimated (Sh-DIN lower). This could be expected because of the differences in the lists of species used and their saprobic values. Assuming the streams sampled represent all available water qualities in the region, these results indicate that the best achievable value for these streams in Limburg is 1.4 for the Sh and even 1.7 for the Sh-DIN.

When only one method for biological assessment is applied for all different stream types, it is impossible to use one single biological classification system for a translation of the saprobic indices to water quality classes. When the best achievable value is 1.7 for a lowland stream, indicating a good water quality, it might indicate a moderate water quality for a mountain stream. This point of view is shared by BRAUKMANN (1984), who described the achievable values of several unpolluted stream types. He used a scale from 0.0 to 4.0 (including xeno-saprobic) and found mean values of 0.7 ± 0.2, 1.0 ± 0.3 and 1.7 ± 0.3 for unpolluted mountain, hill and lowland streams, respectively. This implies the necessity of using different classification systems for different water types when using the same method for biological assessment.

Overestimation by the Sh-DIN compared with the Sh for (heavily) polluted streams is due to the fact that species, indicating this pollution (e.g. *Chironomus*, Hirudinea and Tubificidae), obtained lower saprobic values. The strong influence of only a few species on the calculation of the saprobic index is illustrated in Figs. 2 c and 2 d, where the saprobic values of *Chironomus thummi* and Tubificidae (3.2 and 3.5, resp.) are increased to their original values (3.4 and 3.6, resp.). Since these taxa are very common and present in many samples the effect is quite obvious. The regression line approaches the y = x line, which means that the Sh and the Sh-DIN are more similar. Correcting for the standard deviation and the abundance (Fig. 2 d), the effect is less obvious because the increase of the saprobic values causes an increase of the standard deviation in such a way that the samples with the most obvious effects, are removed because of this raised standard deviation.

The use of this statistical test has the advantage that the results are not biassed. A disadvantage is that many samples cannot meet the statistical requirements. Table 1 indicates that about 60 % of the samples are unreliable according to the statistical test. The standard deviation exceeds the standard more often for the Sh, because of the large saprobic variation of the collected organisms. The abundance is more often below the standard for the Sh-DIN because the species listed are not found frequently. This statistical limitation is a mathematical matter, however, and does not imply that exceeding the standards makes the results useless. Moreover, it should be considered that the ecological reality is not a statistical model. Frequently exceeding the standard deviation may be an indication that some species have been given incorrect saprobic values or are improper indicator species. Another reason might be the ecological phenomenon that collecting from various microhabitats with differing saprobic conditions leads to a wide range of saprobic values.

Not reaching the requested cumulative abundance could indicate that the samples are too small and/or the collected species are not included in the calculation of the saprobic index. However, it is possible that streams only contain few species and specimens caused by organic pollution, while the statistical demands make an assessment unreliable.

The conclusion can be drawn that a statistical approach can be useful in evaluating the reliability and the applicability of saprobic indices. In many situations, however, the statistical guidelines should be interpreted with the biological reality in mind.

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