

Gaps and Uncertainties in the Ecological Status Assessment in the Danube River Basin District

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Abstract The EU Water Framework Directive demands the good ecological status in all surface waters within the time frame 2015–2027. The status is monitored by the member states using national sampling and assessment methods designed after the requirements of the WFD and adjusted in an international intercalibration process. In the implementation process, still gaps and uncertainties exist. For solving the open issues, more data and research is necessary; often countries could use approaches developed by other EU member states.

Keywords Assessment, Danube, Ecological status, Methods, Monitoring, Sampling

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1 Challenge Ecological Status

Since the year 2000 the Water Framework Directive [1] (WFD – Directive 2000/60/EC) commits European Union member states to achieve good qualitative and quantitative status of all water bodies within the time frame 2015–2027. For surface waters the qualitative aspect demands the good ecological and chemical status.

What is the significance of the ecological status? It is an estimation of the quality level of the ecological functionality of the aquatic ecosystem, including the total environment and the extensive network of biota. Ecosystems are extremely complex and an evaluation of their total entity is impossible. Thus, selected organismic groups are serving as indicators that describe the key functionality: fish, aquatic plants (macrophytes and phytobenthos), phytoplankton and benthic invertebrates.

The use of biological indicators for the assessment of ecological quality has a long tradition that started with Lauterborn [2] decades before the WFD was issued. However, most of the early systems concentrated on evaluation of organic pressure and few biological elements, mainly benthic invertebrates and phytobenthos. The WFD is a substantial step forward using the complex analysis of pressures and impacts and the assessment of the status of water bodies. There are normative definitions for the methods for classification of the ecological status, but member states are free to design their own national methodology for sampling and assessment [3]. To ensure international comparability and adjustment of the various methods to a common level, an intercalibration process was foreseen.

The WFD-compliant methods for the assessment of ecological status are type specific. For each type of surface water, reference conditions are defined, and the assessment methods measure the deviation of the actual status from the reference status on the scale of selected parameters. Thus, the challenge for developing the new methods was to differentiate between types; to define reference conditions by using either pristine sites, historical data or a modelling approach; and to find appropriate indices that describe the reaction of the biological quality elements to the relevant pressures.

The European Commission provided general rules for these processes [4], and the detailed implementation on the national level has to be reported to the European Commission.

National River Basin Management Plans (RBMP) contain the information about all the steps in the implementation process of the WFD. At the level of the Danube River Basin (DRB), the ICPDR produced the Danube River Basin Management Plan which is a roof report covering the entire catchment area at the basin-wide scale [5]. Details of this report concerning the monitoring and assessment of the chemical and ecological status were dealt with by the Monitoring and Assessment Expert Group (MA EG) of the ICPDR. This expert group also analysed the gaps and uncertainties within the monitoring programmes in place. Findings of this analysis (status as of 2012) are summarised in this chapter.

Key questions addressed in the gap analysis are as follows: Where are the deficits in the implementation of the WFD requirements? How can they be

overcome? Are there still problems with methods, data and the assessment of water body status? Special attention is given to the assessment of large rivers with the Danube being the second largest and longest river in Europe. Large rivers are especially challenging for reasons of difficulties in sampling and assessing the reference conditions.

2 Sampling Methods

Requirements for sampling methods are given in Annex V of the WFD. In some member states WFD-compliant sampling methods are not available for some of the quality elements (Table 1).

With few exceptions, in the EU countries sampling methods for all quality elements are in place. As the requirements of the WFD result in similar sampling methods all over Europe, the existing sampling methods can eventually be adopted to the special needs in the non-EU countries which still have a need for the development of sampling methods for about 25% of the quality elements.

For large rivers and especially for the Danube, satisfactory sampling methods for the evaluation of the ecological status do not exist for some quality elements. The reason for this is that representative and quantitative sampling for some quality elements requires taking samples from deep areas which is technically difficult and expensive. This is especially the case for fish and macrozoobenthos. To which extent the deep areas have to be sampled remains still unclear.

3 Assessment Methods

Requirements for assessment methods are given in Annex V of the WFD. An overview of the availability of WFD-compliant assessment methods is shown in Table 2.

For each country the assessment is linked to the national sampling methods, because reference conditions for the metrics or indices used depend on efficiency and design of sampling. For example, for macrozoobenthos, the abundance will increase with decreasing mesh size used for sampling. However, for the assessment of the status, the relation of the actual measurement to the reference value is used. Thus the strict definition and adherence of the reference values is more important than the technical details of the sampling method (such as mesh size) as long as the sampling method is efficient in recording the variables of the ecological community required by Annex V of the WFD.

Only in few EU countries, assessment methods do not exist for all quality elements, and for some countries specific quality elements are not relevant (e.g. in some countries even the large rivers do not sustain an autochthonous plankton community).

For large rivers like the Danube, the reference conditions often are not known due to the fact that they are anthropogenically utilised and therefore

Table 1 Sampling methods in the DRB countries

| Do WFD-compliant methods exist? | | | | | | | | | | | | Does WFD-compliant method for large rivers exist? | | | | | | | | | | | |
|---------------------------------|----------------|-------------------------------|------------------|------|------------------|--------------------------------|---------------------|---------------|-------------------------------|-----------------|------|---|--------------------------------|---------------------|--|--|--|--|--|--|--|--|--|
| | Phyto plankton | Macrophytes and phyto-benthos | Macro zoobenthos | Fish | Hydro morphology | General phys.-chem. conditions | Specific pollutants | Phytoplankton | Macrophytes and phyto-benthos | Macrozoobenthos | Fish | Hydromorphology | General phys.-chem. conditions | Specific pollutants | | | | | | | | | |
| AT | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | | | | |
| BA | Y/nc | Y/nc | Y/nc | N | N | Y/nc | Y/nc | Y/nc | Y/nc | N | N | N | Y/nc | Y/nc | | | | | | | | | |
| BG | N | Y | Y | Y | N | Y | Y | N | N | N | N | N | Y | Y | | | | | | | | | |
| CZ | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | | | | |
| DE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | | | | |
| HR | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | Y | N | Y | Y | | | | | | | | | |
| HU | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | | | | |
| MD | Y | Y/nc | Y/nc | N | Y/nc | Y | Y | Y | Y/nc | Y/nc | N | Y/nc | Y | Y | | | | | | | | | |
| ME | Y/nc | Y/nc | Y/nc | N | N | Y/nc | N | Y/nc | Y/nc | Y/nc | N | N | Y/nc | N | | | | | | | | | |
| RO | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | | | | |
| RS | Y | Y/nc | Y | Y/nc | Y | Y | Y/nc | Y | Y/nc | Y/nc | Y/nc | Y/nc | Y | Y | | | | | | | | | |
| SI | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | | | | |
| SK | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y/nc | Y | Y | Y | | | | | | | | | |
| UA | Y | N | N | N | N | Y | Y | Y | N | N | N | N | Y | Y | | | | | | | | | |

Y WFD-compliant method available, Y/nc method available but not compliant, N no method available at the moment (status as of 2012)

Table 2 Assessment methods in the DRB countries

| | Do WFD-compliant methods exist? | | | | | | | | | | Does WFD-compliant method for large rivers exist? | | | | | | | | | |
|----|---------------------------------|-------------------------------|------------------|------|------------------|--------------------------------|---------------------|----------------|-------------------------------|-----------------|---|-----------------|--------------------------------|---------------------|--|--|--|--|--|--|
| | Phyto plankton | Macrophytes and phyto-benthos | Macro zoobenthos | Fish | Hydro morphology | General phys.-chem. conditions | Specific pollutants | Phyto plankton | Macrophytes and phyto-benthos | Macrozoobenthos | Fish | Hydromorphology | General phys.-chem. conditions | Specific pollutants | | | | | | |
| AT | Y/nc | Y | Y | Y | Y | Y | Y | Y/nc | Y | N | Y | Y | Y | Y | | | | | | |
| BA | Y/nc | Y/nc | Y/nc | N | N | Y/nc | Y/nc | N | N | N | N | N | N | N | | | | | | |
| BG | N | Y | Y | Y/nc | N | Y/nc | Y/nc | N | N | N | N | N | Y/nc | Y/nc | | | | | | |
| CZ | Y | Y | Y | Y | Y/nc | Y | Y | Y | Y | Y | Y | Y/nc | Y | Y | | | | | | |
| DE | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | Y | N | Y | Y | | | | | | |
| HR | N | Y | Y | Y | N | Y | Y | Y | Y | Y | Y | N | Y | Y | | | | | | |
| HU | Y | Y | Y | Y/nc | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | |
| MD | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | Y/nc | | | | | | |
| ME | Y/nc | Y/nc | Y/nc | N | N | Y/nc | Y/nc | Y/nc | Y/nc | N | N | N | Y/nc | N | | | | | | |
| RO | Y | N/Y | Y | Y | Y | Y | Y | N/Y | Y | Y | Y | Y | Y | Y | | | | | | |
| RS | Y | Y | Y | Y/nc | N | Y | Y/nc | Y | Y | Y | Y/nc | Y | Y | Y/nc | | | | | | |
| SI | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | |
| SK | Y/nc | Y | Y | Y | Y | Y | Y | Y/nc | Y | Y | Y/nc | Y | Y | Y | | | | | | |
| UA | Y/nc | N | N | N | N | Y/nc | Y/nc | Y/nc | N | N | N | N | Y/nc | Y/nc | | | | | | |

Y WFD-compliant method available, Y/nc method available but not compliant, N no method available at the moment

hydromorphologically modified since centuries. Thus in most countries the assessment methods are based on theoretical reference values that are stated by historical data or a modelling approach.

4 Monitoring Programmes

The proper installation and alignment of the monitoring system is an essential prerequisite of data availability, data quality and data quantity. General guidelines for establishing monitoring programmes are given in the WFD in Annex V. For some EU member states within the Danube River Basin, the following problems still exist:

- The number and the best location of sampling sites within a water body are unclear or too low for a reasonable assessment of the ecological status of the water body. Official requirements for setting the monitoring system (e.g. fixed in a guideline) do often not exist.
- The overall number of sampling sites is too low for an assessment of the ecological status that covers the whole area of the state.
- Data on hydromorphological elements are missing.
- Intercalibration is still missing for some biological methods for individual quality elements. This is a general problem for all EU member states.
- Impossibility of statistical correlations between BQEs and physical and chemical supporting elements because of monitoring data collected at different time periods in the year.
- Lack of taxonomic expertise for the application of complex assessment methods. This is especially the case for macrozoobenthos and phytobenthos.

In the EU countries of the Danube River Basin, only for about 10% of the quality element unclarities exist concerning number and positioning of sampling sites within the water body, while in the non-EU Danube countries, the number and location of monitoring sites is still not clear for more than 40% of the quality elements (Fig. 1).



Fig. 1 Question: is the necessary number and location of the monitoring sites within a water body clear?

Information exchange between the member states is a crucial factor for filling the information gaps in the RBMP caused by problems with the national monitoring systems. Requirements of the WFD result in the application of similar methods all over Europe. This means that the methods existing in EU member states can be used or adapted to the special needs in another country where such method is still not available.

Gap analysis revealed that in many cases higher sampling frequencies would be necessary in national monitoring programmes. The major reason of low monitoring frequencies is financial constraints. It has to be however pointed out that the ecological assessment according to the WFD requires an investigation of environmental variables in relation to their reference conditions. Therefore, it is not always necessary to investigate all seasons and all possible spatial variability. In the event that the reference condition refers to a special time (e.g. the abundance of macrozoobenthos in spring), samples can be also taken only during this time. Applying the adaptive monitoring frequency, it has to be made sure that the conditions for the used variables are robust in time and space.

5 Intercalibration

The intercalibration was included in the implementation process of the WFD to guarantee a similar assessment of comparable ecological status situations with different national assessment methods. At the same time this exercise serves as a quality assurance and control procedure for the national assessment systems. There are numerous reasons of data variability including differences in national typologies, difficulties in defining reference conditions and difficulties in selecting suitable indices that correlate with the applied national assessment methods.

However the intercalibration should serve as a comparison at a coarse level taking into account a considerable variability. Thus in general the data variability is not a major problem as long as the intercalibration process is seen as rough match and adjustments are made carefully and with sense of proportion.

At present two phases of the intercalibration process have been accomplished (for details see Commission Decisions [6, 7]). The rivers of the Danube River Basin have been covered in the Eastern Continental Geographical Intercalibration Group, and the intercalibration is completed for the quality elements, macroinvertebrates, phytobenthos and macrophytes. The quality element fish was intercalibrated for the entire Europe (without separation into types) with the results included in the Commission Decision 2013.

In large rivers the situation is more complicated. Sampling is difficult, and assessment systems are often missing or unsatisfactory due to missing information concerning reference conditions, dominance of alien species and lack of monitoring data. In the Commission Decision 2013, only results for phytobenthos are included; the intercalibration for macrophytes, phytoplankton, fish and benthic invertebrates

is expected to be completed until 2016. Another open issue is the intercalibration of heavily modified water bodies.

6 The Role of Alien Species

In all DRB countries neobiota are a substantial problem for the assessment of the ecological status. On the one hand, they are replacing the native species which is not automatically altering the ecosystem quality substantially, but the effect of this is difficult to evaluate. On the other hand, neobiota are colonising habitats with anthropogenic origin (like flood protection fortifications), making the relation to natural reference conditions impossible. Designing a programme of measures addressing alien species is a very problematic issue which cannot be solved before addressing the question of how to deal with the invasive alien species in the assessment of the ecological status. This question is still being under discussion all over Europe. In reaction to this issue, the Monitoring and Assessment Expert Group of the ICPDR agreed on the joint position that invasive alien species should not be considered en bloc as having a negative impact without further analysis and prepared a list of species with more detailed information. For more information, see Paunović et al. [8].

7 From Monitoring Data to Ecological Status

Data from WFD monitoring programmes are obtained from sampling sites that should be selected to be representative for the whole water body. Until present the criteria of representativeness were not compared or harmonised – intercalibration focuses on the comparison of sampling methods applied at the sampling sites.

In most Danube countries not enough monitoring data is available for an ecological status assessment of all water bodies. Part of the total number of water bodies can be assessed by a grouping procedure that is explicitly allowed by the WFD: A group of water bodies with comparable conditions concerning typology and reference conditions, but also pressures, can be assessed by sampling sites in a representative number of water bodies. The results from these water bodies are then transferred to the whole group.

As often the available data and the grouping procedure are not sufficient for the assessment of all national water bodies, many countries use a confidence concept (Fig. 2) similar to that used in the DRBMP [5]. The basis of this concept is:

- High confidence: assessment by monitoring data or reasonable grouping
- Medium confidence: assessment with insufficient data or grouping

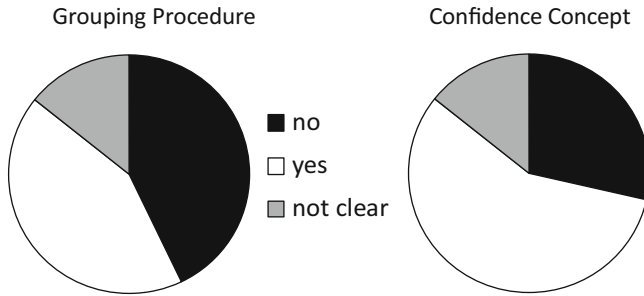


Fig. 2 Use of grouping procedure and confidence concept for the assessment of all water bodies in the Danube River Basin. No: grouping procedures are not used in the national monitoring system, yes: grouping procedures are an integral part of the national monitoring system, not clear: use of grouping procedures in the national monitoring system is still under discussion

- Low confidence: assessment without data, mostly by transferring risk to status (e.g. no risk = good status with low confidence, risk = moderate status with low confidence)

8 Conclusions

The implementation of the WFD clearly promoted progress in the monitoring and assessment of aquatic ecosystems and will continue to be a driving force in future research and development. Nevertheless, the procedure of monitoring and assessment is not in the final stage but will be a process of permanent adaptation and further advancement. Not only gaps concerning sampling and assessment have to be eliminated, but also intercalibration has to be completed, and further challenges (e.g. in the fields of neobiota, climate change and upcoming pressures) will have to be taken into account.

Countries are facing similar problems and gaps; thus, solutions (e.g. typology, methodological approaches) may be acquired together or adopted from existing methods.

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