



NORMAN Working Group 2

The value of bioassays and biomarkers in water quality monitoring programmes: strategies for the interpretation of results

Summary

Technical developments in the past decades have yielded an enormous array of different bioassay and biomarker methods, which are now available to measure effects of toxicants in water. With the occurrence of new substances in the environment, also more specific bioassay and biomarker methods were developed towards specific groups of compounds (e.g. estrogens).

Besides the wide range of available technical methods, many different strategies are used to interpret and/or integrate the results from these measurements. To bring the application of the bioassay and biomarker methods a step further, and illustrate the value of these methods to policy- and decision makers, this working group aims to evaluate the different interpretation strategies used for bioassay and biomarker results. Furthermore attention is paid to the applicability of these strategies for measuring water quality and more importantly for forming water management policy.

Introduction/background

Common water management issues are the identification of local environmental problems, the justification of environmental protection measures or monitoring the success of these measures. Water managers typically have to cope with questions like “Is the water safe to drink?”, “Are the effluents of an industrial plant dangerous for the flora and fauna in its vicinity?”, “Is fauna and flora affected by pollutants (e.g. for WFD)?”. These are typically questions that require an answer that integrates scientific information, preferably at the level of field ecosystems, and information on available resources, practical implementation and conflicting interests. To gain information on the scientific part of the answer, managers have numerous tools at their disposal to measure indicators for the water quality. Traditionally, these are chemical analytical methods, but increasingly also bioassay and biomarker methods are used. However, since all of these methods are *indicators* that are used to answer the initial question, other tools like assumptions or statistical methods are needed to translate the measurement results to a relevant answer.

For chemical analytical methods, these translation tools are for example the linking of concentration levels to toxicity data, i.e. the calculation of risk factors via comparison to standards (which can vary depending on the target use of the water in question). When using bioassays or biomarkers, managers have to cope with similar translation steps to get usable answers to their questions. Depending on the question, a test strategy is chosen (e.g. which bioassay to use, where and how often should it be measured). Collected data are then often further integrated and interpreted, using a suitable interpretation strategy, in order to answer the original question. For example, translation of the test results from individual species in lab tests to populations or ecosystems is an essential step to answer the original question.

Technically, development of different bioassay and biomarker methods has evolved substantially. Many of the bioassay methods are standardized and commercially available. For biomarker methods, standardization is still pending. Bioassays or biomarkers are widely used to measure toxicological effects of water samples on organisms, tissues or biological processes and to indicate general chemical water quality. General tests or specific tests for



one type of effect or one group of compounds, tests using whole organisms (in vivo) or tests using isolated tissue cell lines (in vitro). Each of these techniques has its own pros and cons, possibilities and limitations. In practice, depending on the water management questions, choices are made for one or another test strategy. For this reason, in this Working group we will not exclude any strategies before hand, but rather make an inventory of which strategy is used to answer which question. The focus will be on inventorying test strategies rather than technical methods. These test strategies include the choice for which bioassay or biomarker technique and the reasoning behind that choice, as well as the strategy of interpretation of the collected results, e.g. PAF, pT, Amoebe or toxicity profiling.

It is not the aim to come up with a technical manual or protocol on which tests should or should not be used. Any kind of consideration of bioassays or biomarkers when making policy decisions is already beneficial. It is however very valuable if we can give more insight in the differences between test strategies and the interpretation of their results, not only between bioassay methods but also compared to the classical chemical and biological monitoring methods (i.e. analysis of the chemical and biological parameters defined by the WFD). In the end, the decision-maker has to decide on using a certain strategy or not and whether or not to take the result into account when making a water management decision. By visualizing the pros and cons for each option, we aim to support those water management decisions.

Several steps can be identified for this working group. The first step is making an inventory of available test strategies and evaluate those strategies. A list of knowledge gaps and general attention points will also result from this. One of the follow-ups could be to check if there are any regular monitoring activities in Europe using bioassays or biomarkers. These data, combined with chemical and ecological data could be used as input for a validation of the relationship between biological quality (e.g. as measured in the WFD on the basis of species lists) and effects measured with bioassays or biomarkers. This validation is very valuable for evaluating the value of bioassays and biomarkers for decision makers.

Proposed mandate for the WG

The aim of this NORMAN WG is to find tools to predict effects in aquatic ecosystems in order to protect living organisms in water. We will make an inventory of test strategies using bioassays and biomarkers, including strategies for the interpretation of results and their evaluation. The focus is on the aquatic environment, but tools used for other matrices can be supportive for our inventory.

For this purpose, this NORMAN WG should cover the following activities:

- inventorying of the used interpretation strategies, including definition of the assumptions behind each strategy, and identification of the strategy for interpretation of the results and the associated uncertainties. Part of this inventory could be the assemblage of information from existing or past projects and from existing or planned monitoring activities.
- discussing critical issues about the benefits, assumptions and uncertainties in the interpretation of bioassay results and the needs/requirements to allow the operational use of these tools for decision-makers; the result will be a list with alternative interpretation strategies and the possibilities and limitations in their use and knowledge gaps. A position paper could summarize these results.



Workplan / Roadmap for 2009

Inventory and discussion of available test strategies and interpretation strategies for bioassays and biomarkers used in environmental monitoring programs:

- Inventory of available test strategies. Which strategies are used to answer which questions? (applications, specificity, etc.)? Summarized in a table, we aim to give an overview of used test strategies and their pros and cons. This table could include the following characteristics:
 - Short description of management question and methods and strategies used.
 - How are these strategies used? Is there a sample treatment step (e.g. concentration) before performing the bioassays?
 - Which assumptions are associated with these strategies?
 - How are results interpreted (handling uncertainties, reference selection, data integration, etc.)? Which standards are used for this interpretation? Is there an integrating step in the interpretation when a battery of tests is used?
 - What are the levels of uncertainty associated with the results? How are they quantified? How are they communicated?
- Discuss and recommend interpretation strategies for the identified management questions. What are the needs for research on bioassays and biomarkers for further applications in biomonitoring? The setup for this discussion could be made during the 1 day workshop in October 2009.
- Collection of the results of the experiences on test strategies using bioassays and biomarkers in the different countries, including the results of projects such as REBECCA, MODELKEY, OSPAR, MEDPOL, ToxProf, FIRE, LOES, EDEN, SOCOPSE, NOMIRACLE, ACE project etc, but also projects outside the scientific scene. We would like to showcase the success stories here.
- Check availability of regular monitoring studies combining bioassay or biomarker test strategies and chemical, but especially ecological monitoring data. The result could be used as a starting point for further validation of methods, if this is found necessary during discussions in the working group.

Deliverables for 2009:

1st draft of position paper containing:

- Goals of the WG (from this mandate) and results of the discussion on the 8th of October
- Inventory (table with test strategies) and evaluation (results from discussion meeting) of interpretation strategies used (including benefits, assumptions, uncertainties and type of question to be answered).
- List of projects that use bioassays or biomarkers (to be uploaded in the EMPOMAP database).
- List of current monitoring activities using bioassays or biomarkers (data to be uploaded in the NORMAN EMPODAT database). In this list we would like to showcase success stories: projects where chemical, but mainly ecological and bioassay data is collected and integrated. This could serve as a basis for a validation step in the future.
- Conclusions could be: which interpretation strategy / translation step is suitable for what goal.



Prospective for 2010

Drafting of the final version of the position paper, including final uploading of the data on current monitoring activities using bioassays and biomarkers in the NORMAN EMPODAT database (planned deadline: June 2010).

Moreover, depending on the results from the discussion and inventories, we will identify knowledge gaps and data needs. For example, the outcome of our 2009 study could be that we need more information to better link bioassay- and ecological monitoring data. We could organize a common comparison study, in which WG2-partners would measure chemical and biological parameters (as they would already do for the WFD) and in addition, measure water quality using bioassays on the same locations. This should result in a list of minimum requirements for uncertainty or reliability of bioassays used for different questions and an advice on factors to be taken into account when interpreting the results. The study will be suited to underpin the scientific value of bioassay results when used for monitoring with different goals.

Organization of the work

Co-ordination: INERIS in collaboration with RIVM, IVM, AD eco advice

Working Group:

See table of participants

Most of the work / exchanges will be organized via e-mail and teleconferences in order to reduce travelling costs.

Two meetings were organised in 2009:

1. Kick-off meeting of the WG (28th of May) coordinators. Participants: IVM, RIVM, INERIS and AD eco advice.
2. Meeting 8 October 2009: first discussion and first inventory of interpretation strategies
Location: IVM (Amsterdam)