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ONEMA
Meetings

Good status of aquatic environments based on the scientific concepts of ecological engineering

A meeting organised by Onema and the Scientific council on water and aquatic environments.

The goal of the meeting, held during the international congress titled *Ecological engineering, from concepts to application* (CNRS, Paris, 2-4 December 2009) for the scientific community working in ecological engineering, was to shed new light on the issues involved in maintaining and restoring the quality of aquatic environments. The point was to take a new look at attaining good ecological status as defined by the European water framework directive (WFD) on the basis of ecological-engineering concepts, without undertaking a complete review of the methods used in this field.

The water framework directive (WFD) created a new paradigm in understanding the ecological status of water in Europe and produced remarkable scientific and technical advances by setting up integrated evaluation processes that inform on changes in the status of aquatic environments. The purpose of the meeting, «*Good ecological status of water: progress report, conceptual limits and scientific opportunities*», was to contrast this understanding of water status with the scientific concepts underlying ecological engineering.

The latter are based on an attempt to reconcile our human societies with the environment. The standard definition of this discipline is «the design of sustainable ecosystems integrating human society and its natural environment, to the benefit of both». The health of ecosystems is one of the founding principles of ecological engineering. An ecosystem is in good health if its organisation and autonomy are sustained over time and if it is resilient to any stresses to which it is subjected. To target the good health of an ecosystem means to «take care» of it. That implies a shift from a curative rationale to one of maintaining a precious asset.

The Water framework directive

The WFD has completely renovated European water policy in view of protecting and restoring the quality of water and aquatic environments. The overriding environmental goal is to restore water to «good status» by 2015. For surface waters, good status concerns both the ecological and chemical aspects. For groundwater, it concerns the chemical and quantitative aspects. Success will consist in not deteriorating water resources and environments for those water bodies already seen as having good status and of implementing the measures required to achieve the environmental goals for subpar water bodies.

The goal of the Water framework directive is to restore water to good status by 2015.

Philippe Maire, Rhine-Meuse water agency

For a Water agency, research in the fields of diagnostics and ecological engineering is important for three reasons. First, monitoring of aquatic environments and their evaluation are based on highly integrated indicators, e.g. ecological status. The reliability of these indicators can and must be enhanced through ecological engineering. That will be an essential condition to obtaining economic and social acceptance of the required efforts. Secondly, knowledge on the links between pressures and impacts is indispensable in order to optimise restoration projects for aquatic environments. We need to know how the environment will «respond» if we reduce a given pressure. And which pressures should be reduced first and for the least cost to restore a water body to good ecological status. Finally, progress in ecological engineering will produce more and more innovative, alternative techniques increasingly well adapted to the task of restoring environments. All the above progress is required to improve restoration projects for which the Water agencies provide installation owners with technical and financial assistance.

A better understanding of the links between pressures and impacts

Sandra Poikane (Joint Research Centre, European commission) highlighted the WFD requirement that the ecological status of water bodies be evaluated using a series of indicators based on the observation of aquatic fauna and flora. In fact, four categories of quality elements are taken into account to develop the indicators, i.e. phytoplankton, aquatic flora, benthic invertebrates and fish. The definition of «good ecological status» for water bodies is based, for each indicator, on a reference state and thresholds between five status conditions. Good ecological status corresponds to a minor divergence from the reference state, i.e. that of an undisturbed environment (figure 1). Changes in the ecological status of an environment are plotted as a function of the intensity of the pressure

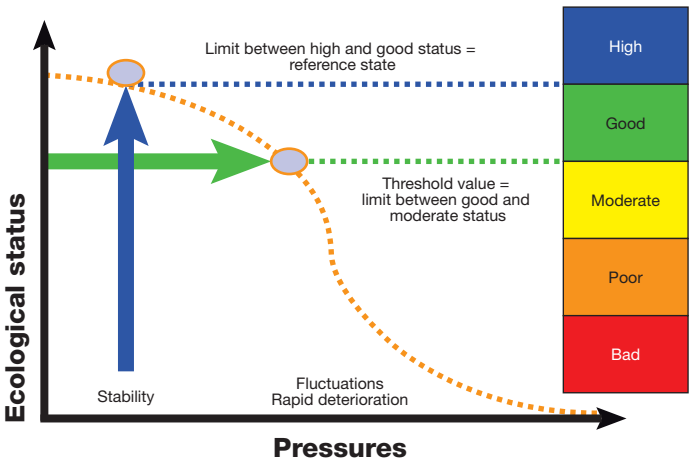


Figure 1. Changes in the ecological status of an environment as a function of the intensity of the pressure gradient. The WFD translates the changes into five status classes. Source: Sandra Poikane, 2009.

gradient, according to a non-linear relation. A return to good status is not a linear reaction to a reduction in the pressures weighing on the environment. Better knowledge of the links between pressures and impacts on biological aspects should make it possible to go beyond evaluating the ecological status and to zero in on how an environment functions, its disturbances, and thus to determine the possible management and restoration measures. In particular, it is most important to understand the effects of the combined action of different pressures and to distinguish between natural variation and anthropogenic variations.

Cultural heritage and reference state

Jean-Marie Mouchel (University of Paris UPMC and PIREN-Seine programme) noted that «good ecological status» is defined as a minor divergence from a reference state for which we do not necessarily have a common data repository. Scientists base their quality evaluations of water bodies on taxonomic indicators that take into account spatial differences, but often do not incorporate variations over extended time periods. Jean-Marie Mouchel holds that a long-term approach to indicators could be a means to better define the reference state and enable better communication between scientists and citizens on the issue of «good ecological status» because it would take more into account the services rendered to the population.

For example, in the Seine basin, the quality of surface water is, on the whole, better now than in the 1950s to 1970s, thanks to treatment of wastewater. The quality of groundwater, however, has dropped, due notably to increased use of nitrates and pesticides in agriculture (figure 2).

Based on studies of farming and forestry practices and hydraulic installations in the

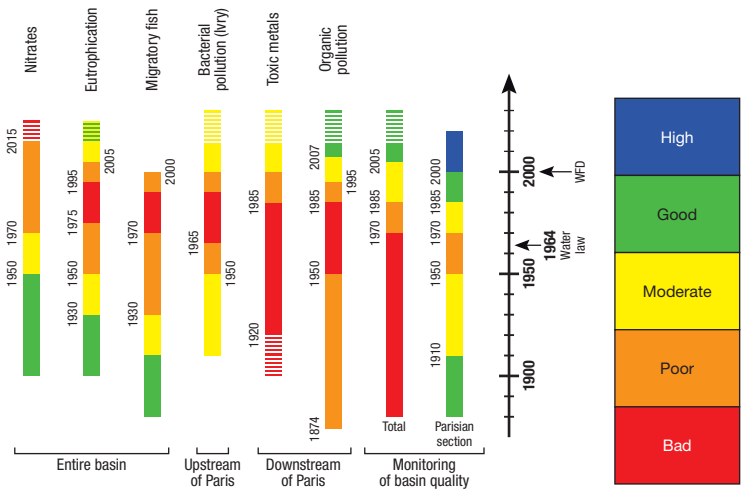


Figure 2. Changes in the water quality of the Seine river. Source: Michel Meybeck, 2009.

Middle Ages, carried out for the PIREN-Seine programme, Jean-Marie Mouchel notes that the nitrogen cycle at that time was totally closed and sustainable.

He also observes that many canals and mills were built at that time to meet the needs of the population. Some of those systems are still in use today. Should they be considered a cultural heritage or as modifications in the reference state making it necessary to go back even further in time? These issues raise questions on how to define a « reference state » and to take historical aspects into account. Further, even the best initial state may be very different than the current state and not reproducible.

Reaching a new sustainable state

A useful explanation of the scientific concepts underlying ecological engineering in view of understanding WFD implementation is based on an analysis of the difference between ecosystem restoration and the maintenance of ecosystems in good condition. To restore ecosystems, it is necessary to identify an undisturbed initial state that is set as the goal to be reached. But how should the initial state be defined? Should all human modifications to ecosystems be considered disturbances or should we assume that humans are part of the ecosystem and that certain modifications that not alter ecosystem sustainability may be accepted as characteristics of the initial state of the ecosystem? If we see the goal of ecological engineering as the good health of ecosystems (and of humans), then we can avoid the problem of defining a reference state by focusing on ecosystem operation, sustainability and the services made possible. The goal is thus not to return to an initial state, but to reach a new, sustainable one. The ecosystem is capable of adapting and finding a balance in a changing environment, and of supplying services to the population. But defining indicators capable of expressing a systemic view of environmental operations and of measuring the adaptive capacity of environments (the health of an ecosystem or water body) still requires a great deal of research.

Modified social dynamics

Patrick Steyaert (INRA) thinks that WFD implementation profoundly modifies the social dynamics of a given territory, i.e. the social relations between people, their understanding of the effects of their activities on the environment, changes in behaviour. Management of these social dynamics, interacting with the natural dynamics linked to ecosystem operation, will be the main challenge for WFD implementation in the decades to come.

To take these dynamics into account, we must rethink how we use scientific knowledge for the WFD, so that it can explain complex situations involving change and encourage social interaction concerning problems in environmental management (figure 3). To date, many experts and scientists have produced

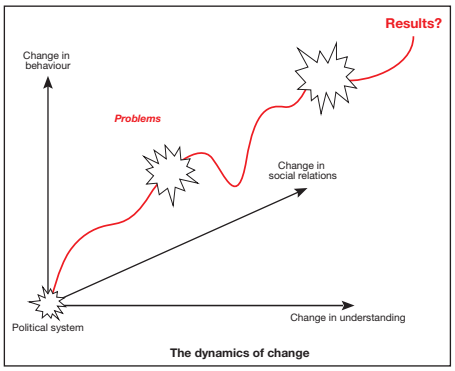


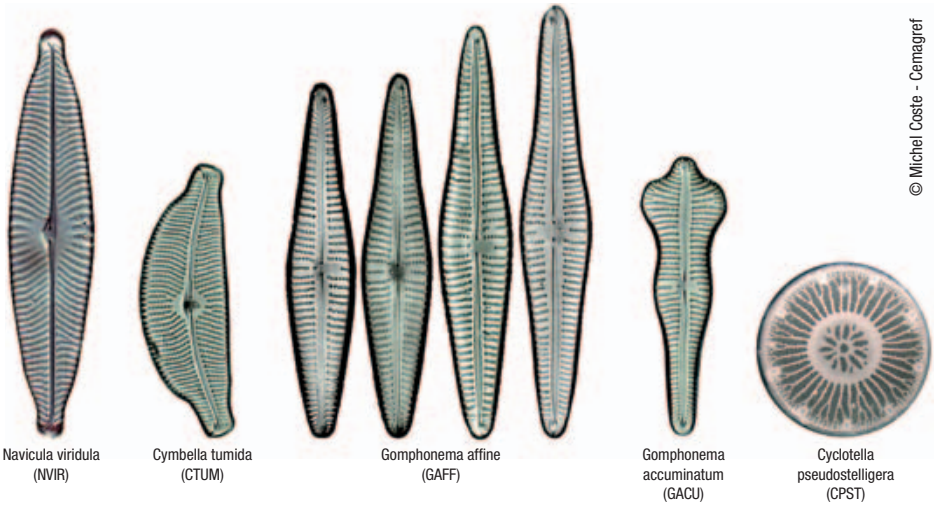
Figure 3. Natural and social dynamics applicable to the quality of aquatic environments for the WFD. Source: Patrick Steyaert.

knowledge or developed indicators to evaluate water quality, economic tools to assign costs to environmental deterioration and models to define management goals and provide the means to evaluate the work done. This knowledge is produced and used in a manner that is primarily prescriptive in nature and that targets a result, with no questions raised as to how it is used in the learning process among the different players that is initiated by WFD implementation. This learning process, which raises the question of how we perceive technical and social change and decision-making in public environmental policy, has not been extensively studied and essentially remains a « black box ».

It is thus necessary to develop a framework to reconcile the various approaches to mobilising and producing scientific knowledge in support of policy implementation. This in turn requires an analysis of how public action is organised and of the role granted to systems for territorial collective action in defining management problems and in designing change.

Martin Arnould,
WWF and member of the Scientific council

I have experienced a feeling of helplessness concerning good ecological status. For many decision-makers, the issue is not to scientifically characterise a dynamic ecological state, but to reinforce the legitimacy of the concept for citizens so that it can be used as a tool for action and to modify behaviour. If we want to reach the goals set by the WFD, we must put more thought into how to encourage public participation and dialogue.



Examples of biological indicators of good status (seen using a photonic-force microscope).

Giovanni Bidoglio,
Joint Research Centre and member of the Scientific council

Until now, there were no methods to draw up a status report on the ecological quality of aquatic environments. That is one of the major results of the WFD, in that it obliged scientists to sit down together and attempt to define a consistent set of methods. Those methods must still be optimised to enhance monitoring of ecosystem dynamics.

« Biomanipulation », a Danish example of environmental restoration

Above and beyond concepts, the scientific methods of ecological engineering applied to aquatic environments offer a number of concrete tools to restore the quality of environments. An interesting case of « biomanipulative » restoration in lakes suffering from eutrophication was tested in Denmark. It was presented by Erik Jeppesen (National environmental research institute, Denmark).

Shallow lakes often suffer eutrophication due to high inputs of nutrients, caused by household wastewater as well as industrial and agricultural effluents. Major efforts are now made to return to a non-eutrophicated state in order to improve water quality and the ecological quality of lakes, particularly in Europe thanks to the WFD. It is necessary to reduce nutrient inputs, but that encounters difficulties for both chemical and biological reasons because eutrophication is not a mechanism that can be reversed in a linear manner. To accelerate recovery, several methods have been developed. One management technique comes from the field of ecological engineering. It consists of influencing food webs in lakes by reducing the biomass of zooplankton-eating fish (small perch, roach, catfish, etc.), which in turn reduces algal biomass and thus returns the lake to a non-eutrophicated state. This technique was used in 27 lakes in Denmark and has produced promising results. However, depending on the lake, highly variable response times have been observed. In addition, this technique produces only short-term results and must be repeated at least every ten years to stabilise the situation. The need to adopt a combination of approaches, affecting the biological (food chain), chemical (reduction in nutrient inputs) and physical (sediment management) regulatory systems, was stressed as the most effective path to success.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Roach are a key species for biological regulation.

Topics for research

The meeting, titled Good ecological status of water - progress report, conceptual limits and scientific opportunities, was organised as part of the ongoing work of the Scientific council on water and aquatic environments. During the presentations, the Council noted a few major challenges, related to the WFD notion of good water status, for the scientific community working in support of water policy. They concern the shift to more dynamic evaluation of aquatic-ecosystem operation to determine the capacity for adaptation and better integration of the social dynamics involved in reaching this public environmental-policy goal.

At the end of the meeting, the Council work group for the « Formulation and implementation of public policy » suggested gathering the existing knowledge and positions for which a consensus exists in order to promote a more dynamic concept of the good ecological status of water. Among other aspects, the goal is to put this knowledge to work in a certain number of fields such as ecosystem operation or the creation of « socio-indicators », in view of evaluating the results and the effectiveness of public policies.

For more information on the meeting:
http://www.biologie.ens.fr/eeca/

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