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Assessment of the environmental status of the coastal and marine aquatic environment in Europe: A plea for adaptive management

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ABSTRACT

Policymakers and managers have a very different philosophy and approach to achieving healthy coastal and marine ecosystems than scientists. In this paper we discuss the evolution of the assessment of the chemical status in the aquatic environment and the growing rift between the political intention (precautionary principle) and scientific developments (adaptive and evidence-based management) in the context of the pitfalls and practicalities confronting the current Marine Strategy Framework Directive (MSFD).

The conclusion is that policymakers and water managers should move with the times and take on board new techniques that scientists are using to assess chemical status and apply new scientific developments in assessment studies of the chemical status. These new techniques, such as bioassays, are cheaper than the classic approach of checking whether concentrations of certain individual priority compounds comply with permissible thresholds. Additionally, they give more insight into the real impacts of chemical compounds.

1. European directives

The most important European legislation for assessing the ecological and chemical status of European fresh and coastal aquatic ecosystems is the EU Water Framework Directive (WFD), which came into operation in 2000 (Anonymous, 2000) and the recently introduced EU Marine Strategy Framework Directive (MSFD) (Anonymous, 2008). The MSFD and WFD aim at maintaining and improving the aquatic environment by arresting long-term deterioration of fresh, coastal and marine ecosystems and water quality. They are a major step forward because they have a mutual common goal: a good ecological and environmental status for which a good chemical status is a prerequisite. This is one of the most topical challenges facing policymakers, water managers, and scientists.

As a result of the MSFD is the assessment of a Good Environmental Status (GES) and of the associated chemical status of the aquatic environment in Europe. There are two management philosophies on how the GES can be obtained. The first is the precautionary principle and the other is based on evidence-based science and adaptive management.

The precautionary principle was defined and applied by OSPAR in the 1980s (Anonymous, 1980, 1987). In general, the precautionary principle is based mainly on fear of the unknown, the unexpected and the possible hazard and directs threats. This philosophy is understandable, given the state of knowledge of human impact on the aquatic environment at the time. In general, its approach is to stay on the very safe side and to achieve near-zero anthropogenic emissions of matter and energy into the environment. In general, the precautionary principle does not take into account new scientific developments and findings (Anonymous, 1980, 1987). By contrast, adaptive management takes scientific developments fully into account; it is evidence-based and is a learning process. Furthermore, it is based on reducing uncertainties, considering possibilities and calculating risks. Whereas the two EU Water Directives are based on the precautionary principle, the Green/Blue Book of the European Marine and Maritime Policy has taken a more evidence-based scientific approach towards sustainable development and an ecosystem-based management for the oceans and seas (Anonymous, 2007).

In this paper we will discuss the historical development of the assessment of the chemical status in the aquatic environment. The benefits of adaptive management in respect to the precautionary principle will be discussed in the context of the pitfalls and practicalities the current MSFD faces.

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2. Caution with precaution

In general, the precautionary principle regulates the discharges of chemical compounds. It states that if there is reason to assume that chemical compounds could cause an effect, their emission should be reduced. The final goal is near-zero emission of anthropogenic chemical compounds. So, this rule is applicable even when there is no scientific evidence to prove a causal relationship between the emission and effect. Merely suspecting a relationship is sufficient reason to take action.

The precautionary principle was a laudable first step to tackle human impacts on the environment. It is based on the idea that if a chemical compound has entered a river, sea or the oceans it is nearly impossible to take measures to remove it from the water.

Criticism of the precautionary principle emerged over 20 years ago, when Gray (1990) pointed out that it is based on a management philosophy that involves no science and that its legitimacy is solely administrative and legislative. His views triggered a discussion about broadening the principle. Points raised were:

- Introducing uncertainty as an important factor in assessment studies. Johnston and Simmonds (1990) and Peterman and M'Gonigle (1992) argued that statistical information is most important and that in order to be able to take appropriate mitigating measures, the accuracy and precision of monitoring and the statistical probability of the findings must be known;
- Assimilative and environmental capacity (Stebbing, 1992) and ecological risk assessment (Fairbrother and Bennett, 1999). Pravdić (1985) used the phrase "assimilative and environmental capacity" to describe a system's potential for coping with pressure without any significant ecological impact.

Taking into account attention to uncertainty and to the environmental capacity concept is a relatively large deviation from the prevailing precautionary principle. It is generally assumed that every system has the capacity to cope with disturbances. The most sensitive effect is what sets the permissible limits or targets. So, a zero load of certain chemical compounds is not necessary in the environmental capacity concept. When applied to the coastal and marine environment, this approach is called the critical load concept (Hindar et al., 2002; Laane, 2005).

However, environmentalists and policymakers have argued that the critical load method is not applicable to chemical compounds because it permits a certain load of a chemical compound in the environment. They saw acceptance of this certain load as a licence to pollute. To spare the aquatic environment from the deleterious effects of anthropogenic chemical compounds, they retained their protective precautionary vision and associated conservative strategy. Initially, the precautionary principle was applied to toxic and bio-accumulative chemical compounds. In time, its scope was broadened to cover all chemical compounds and the entire environment (Anonymous, 2002; Coquery et al., 2005). However, it is clearly impossible to analyse all chemical compounds present in the environment.

3. Select and protect

Environmental chemistry became a major discipline in the 1960s as a result of industrialization and the associated chemical pressure on the environment. In the 1960s and 1970s it was recognized that the aquatic environment in the western world was heavily polluted and was suffering from the effects of unknown chemical compounds and of the relatively low oxygen concentrations (Salomons et al., 1988; Van Leeuwen and Vermeire, 2007). Rachael Carson succeeded in alerting the world to the problem of chemical substances in the environment as a result of the publication of her book Carson and Silent Spring (1962), in which she described the effects of chlorinated pesticides on organisms. Subsequently, many publications and reports appeared describing negative effects of chemical compounds on organisms.

Over time, the attention paid to certain chemical compounds changed (Fig. 1). In the 1950s and 1960s the growth in oil transport by sea and the associated oil pollution on beaches led to more scientific research on to oil and oil derivates (Cowell, 1976). This was also the case for radionuclides: the testing of nuclear bombs in the atmosphere and the ease of using Geiger counters made it possible to study these compounds nearly everywhere.

It must be remembered that to date, priorities have been assigned mainly on the basis of technological development. Fifty years ago, it was difficult to analyse pesticides with gas chromatography (Bernes, 1999). In the 1970s it became possible to measure the concentrations of various metal compounds in water (Bryan, 1976). Ten years later it became possible to isolate and analyse chlorinated hydrocarbons, such as certain pesticides and polychlorinated biphenyls (PCBs) by using gas chromatography – mass spectrography (Bernes, 1999). Initially, attention focused on hydrophobic compounds such as chlorinated pesticides and PCBs, but later compounds such as polycyclic aromatic hydrocarbons (PAHs), dioxins and brominated flame retardants were included (Arnot and Mackay, 2008).

Around 2000, special attention was paid to organic metallic compounds such as the organic lead compounds in fuel and tributyltin compounds (TBT) in antifouling paint, because toxicological effects (imposex/intersex) had been observed in coastal and marine gastropods (Matthiessen and Gibbs, 1998).

Nowadays it is possible to analyse every individual chemical compound (Laane et al., 2005b). However, it is too costly and impracticable to analyse and assess all the individual chemical compounds present in the aquatic environment (De Zwart, 2005). In addition, analyzing all chemical compounds does not tell us how much these chemical compounds individually and in combination contribute to the contamination and to the pollution of the aquatic environment.

The strategy the EU adopted was one followed by other countries and conventions: to produce a list of priority pollutants. This was necessary because nearly every European country had its own list of priority compounds. Though some of the chemical compounds occurred on all the lists, there were large differences between the lists. The chemical compounds common to all lists included lead and PCBs – often based on criteria such as three of the characteristics of chemical substances: persistence (P), bioaccumulation (B) and toxicity (T).

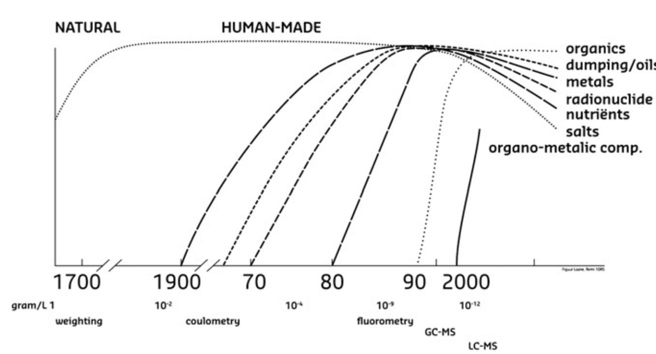

Fig. 1. Attention paid to groups of chemical compounds from the 18th century to the 21st century. The *x*-axis shows the timeline and also indicates the improvements made in the detectable amounts and the time at which equipment capable of detecting these amounts came into use.