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Quality standards and monitoring as water management tools: the case of nitrogen in rivers in France and Brittany

Catherine Carré[a], Alexandra Boccarossa[b], Emmanuelle Hellier[b] and Nadia Dupont[b]

[a]*Corresponding author. Université Paris I Pantheon-Sorbonne, UFR 10 Philosophie, Paris, France*
E-mail: carre@univ-paris1.fr
[b]*University of Rennes 2, Place du recteur Henri Le Moal, CS 24307 – 35043, Rennes CEDEX, France*

Abstract

Water quality standards (QS) and river monitoring are widely accepted as preventive management strategies for the preservation of watercourses and at the same time they are criticized for imposing universal threshold values, leading to regulatory rather than voluntary action. Based on the example of nitrate, the article explains how QS applications are the result of national or regional negotiations, with no direct link to the scientific foundations underlying the development of these tools. These conflicting perceptions and how these tools are actually used are illustrated by the situation in Brittany. Here, the monitoring network and actions to prevent increasing nitrate concentrations in rivers form part of regional programs set up jointly by all the main stakeholders. However, while QS can act as an alarm signal, their effectiveness depends on local political support, which depends on the extent to which river quality is recognized as a key factor in regional development.

Keywords: Monitoring; Nitrogen; Quality standard; River quality; Water management

Introduction

Environmental quality standards (QS) are frequently used in European environmental policies as an instrument for public action. As a policy guideline, an environmental quality standard aims to regulate the effect of human activity on the environment by setting standards to protect or improve environmental quality. Generally defined by law, it is described as ‘a limit for environmental disturbances, in particular, from ambient concentration of pollutants and wastes, that determines the maximum allowable degradation of environmental media’ (OECD, 2003).

European environmental policies highlight the principles of precaution, prevention and rectification of pollution at source. Application of these principles involves different regulatory tools, including

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command-and-control instruments. 'The principle is to command people or firms not to do something by enacting a law that makes it illegal and by delegating authorities to enforce such law through the imposition of fines or penalty to violators (…) As for ambient standards, these refer to 'never-exceed' levels for some pollutants in a particular environment' (Elazegui, 2001).

Considered as tools for controlling pollution at source (Metz & Ingold, 2014), standards and monitoring theoretically serve as a signal, alerting managers to changes in water quality, together with the means of responding to it. Monitoring and evaluation have thus become the key components of European water management policies, with the aim of achieving results in line with the threshold values. They are 'essential prerequisites for learning for any adaptive governance and management approach. This implies setting tangible short-term targets for assessing success or failure and implementing transparent processes with respect to who decides on which kind of evidence is required for the adjustment of policies and/or measures' (Pahl-Wostl, 2015).

However, these instruments have been particularly criticized by political and management scientists who see them as tools imposed by a central authority on behalf of the public interest: 'an interventionist form of public regulation (…) related clearly to the classic conception of representative democracy' (Le Galès, 2011); 'Typically, control is exerted centrally, adhering to rigid and detailed plans for the fulfillment of established goals' (Pahl-Wostl, 2015). They can thus meet with incomprehension or even resistance at the local level.

QS are legally binding and as such may trigger management decisions. In France, they set the values that managers have to achieve. At the same time, judges base their interpretations on these threshold values when examining cases, whether these concern the production and distribution of drinking water, or environmental protection. With regard to nitrate and the production of drinking water, they adhere strictly to a threshold of 50 mg/L.

We will use the example of nitrate monitoring in Brittany to examine how river QS and monitoring can mobilize local and regional stakeholders in the preventive management of surface-water quality.

In France, nitrate has been monitored since at least 1971 by the networks of the water agencies. One of the reasons for this long-standing measure is that it is relatively easy to carry out, in terms of both sampling and laboratory analysis; moreover, it is not expensive.

Breton rivers' monitoring shows a strong growth in the 1980s–1990s and concentrations well above 50 mg/L, with a decline that began in the early 2000s (Observatoire de l'Environnement en Bretagne, 2015). This decrease is the result of a mobilization of regional actors to protect the drinking water resource first. Even if nitrate levels appear to be decreasing since 2006, in 2015 the average regional nitrate ($Q90 = 33.6$ mg/L) is still above the values recommended by scientists to limit eutrophication in Breton coastal bays. Today, nitrate has become a parameter used for both human and animal health, with a drinking-quality standard of 50 mg/L, and for environmental quality of rivers and coastal waters, here with only a suggested criteria ranging from 5 to 10 mg/L (Pinay, 2017).

As such, French rivers have been monitored well before the introduction of the European directive of 21 May 1991 regarding urban wastewater treatment (91/271/EEC) and the Nitrates Directive of 12 December 1991 concerning pollution caused by nitrate from agricultural sources (91/676/EEC). Nevertheless, the European Union (EU) deemed that these directives were not being applied satisfactorily. Brittany was singled out as one of the French regions with particularly poor water quality and taking inadequate steps to rectify the situation. In 2001, the EU accused France of not respecting the statutory regulations regarding nitrate in 37 rivers in Brittany producing drinking water. On 30 June 2011, the Directorate-General for the Environment in Brussels addressed a letter expressing surprise that 25,000 m^3 of green algae had been collected on the Breton coast, double the amount collected in 2010.

The criticisms of the EU were not about inadequate monitoring but about the inadequate measures taken by the French state, criticisms also shared by the regional actors. On a complaint lodged by a Breton association, Eaux & Rivières de Bretagne, on 12 April 2013, the administrative court of Rennes condemned the French state to compensate the county council of Côtes-d'Armor by more than 7 million euros for its actions on prevention and treatment of green algae committed from 1975 to 2009.

All these reasons make the Breton case particularly interesting to study, nitrate being a long-term monitored pollutant, whose effects on drinking water and aquatic environment are well documented (Burt *et al.*, 1993) as measures to reduce concentrations in watercourses (Clement *et al.*, 2002). However, if the regional actors have been engaged since the 1990s in programs to reduce the nitrate concentration in the rivers, based on its monitoring to make all polluters (domestic, industrial and agricultural) accountable, they have met a lot of resistance and results are still insufficient, at least with regard to the proper functioning of coastal environments, according to the 2017 national expertise on eutrophication (Pinay *et al.*, 2017).

In this paper, we examine why regional actors in charge of water management decided to monitor nitrate, how monitoring data were interpreted according to QS, and their use and utility to initiate measures in favor of rivers' quality recovering. In this sense, the analysis that we present is quite original and, to our knowledge, has no academic precedent, likely for the following reasons.

The first reason is the small number of countries where it is possible to conduct this study, because it requires long-term monitoring of watercourses with data acquired according to measurement protocols and correct laboratory analyses. The existence of this type of monitoring concerns mainly American and European countries, and only on physicochemical quality (on the Thames river, see Howden *et al.*, 2010; on the Seine river, see Meybeck *et al.*, 2016).

Another reason lies in the focus of science and technology research on the challenges to be met in order to improve the efficiency of these measurement tools or to produce 'more efficient generation of water quality data (…) to provide new insights into causes and impacts of variations in water quality in other large international river basins' (Chapman *et al.*, 2016).

The study of monitoring in water management has been done either to improve the functioning of the physicochemical parameters measurement tool for the production of drinking water (Altenburger *et al.*, 2015) or to evaluate the effectiveness of equipment and actions to reduce pollution – such as the effects of treatment plants and the adequacy of their treatment levels with pollution, including emerging pollutants (Jones *et al.*, 2017) — but has not been done on the management of rivers to improve their quality.

Taking nitrate as a water quality parameter is thus a way of examining the use and usefulness of QS and monitoring in regional water management. Do they function as tools that alert river basin managers to the degradation of water and environmental quality? What is the role of the monitoring networks in moving from measurement to action?

Methods

Our approach is based on the analysis of public policy instruments (Le Galès, 2011), taking QS and the monitoring stations as 'sociological institutions'. It focuses on the analysis of two dynamics:

first, the construction-adaptation of these instruments, their integration in the sectorial mechanisms of public action and the grounds for choosing them; and second, their appropriation by stakeholders, resistance to them or conversely the propositions that are made, and the various effects that they may have both on the networks involved and on the issues at stake, and the feedback effect on the instrument itself.

The elements of analysis reported in this article are based on a research program, Makara, on water quality in several French river basins, notably the Seine, the Loire and rivers in Brittany. We examined how these standards have been appropriated for water management at the regional level, and the monitoring systems that have been set up to meet the objectives of these regulations.

Brittany is of particular relevance in this respect, as the nitrate pollution of its rivers has been a political problem at the regional level since the 1990s, involving the public and private sectors. The results of this part of our study are based on Alexandra Boccarossa's thesis (Boccarossa, 2018). She has investigated the specific role of the Breton monitoring networks that have been set up to complement the Loire-Bretagne water agency network. Interviews were conducted with the main stakeholders involved in regional water governance (Richard *et al.*, 2010), with a view to examining specifically the link between scientific knowledge of the nitrate problem in Brittany, the implementation of river monitoring mechanisms, and the actions taken by the public authorities responsible for river quality. Three types of public stakeholder are concerned: (1) the water agency technicians and members of the basin committee who cannot initiate projects but grant funding; (2) elected representatives of the local structures, responsible for organizing water supply and treatment of wastewater; (3) regional government, *régions* and *départements*, who are in charge of economic and rural development and consider water as a key issue in local politics.

It is these regional stakeholders who set up the water management plans in Brittany in the 1990s, called the BEP programs (*Bretagne Eau Pure*), in response to the closure of drinking-water catchments where the nitrate level was above the permitted threshold. Local structures were set up in each river basin to monitor nitrate concentrations in watercourses, and to initiate actions with farmers. This analysis focuses on the case of the Grand Bassin de l'Oust (GBO). The GBO is a regional structure almost unique in Brittany (see Figure 1); created in 1998 as part of the first BEP programs, it covers eight river basins, including the Yvel-Hyvet catchment with a surface area of 37,560 hectares, located in the *départements* of Côtes d'Armor and Morbihan, and the second-largest water reservoir in Brittany to produce potable water, the Lac au Duc. The GBO is composed of municipal councillors and a technical team of 10 people (river technicians and agricultural counselors). The GBO's aim is to implement programs to restore water quality and achieve good ecological status of the watercourses. Monitoring rapidly played a key role in formulating problems of quality and their solutions.

For the purpose of this article, we have studied how all these public actors have used the nitrate standards to prioritize actions and to construct their water quality monitoring networks. As our study was largely based on discourse analysis, we illustrate these points using quotations.

After presenting the results in the sections below, we will discuss the effect of the standards and monitoring strategy as preventive management tools for regional water quality. Does the combination of monitoring and QS provide an effective signal to trigger action? Do the standards identify a local problem and incite stakeholders to act? More basically, are QS top-down tools, imposing objectives that have been agreed at the European level on the regions, or do QS and monitoring provide the opportunity to raise concerns and issues about local water quality?

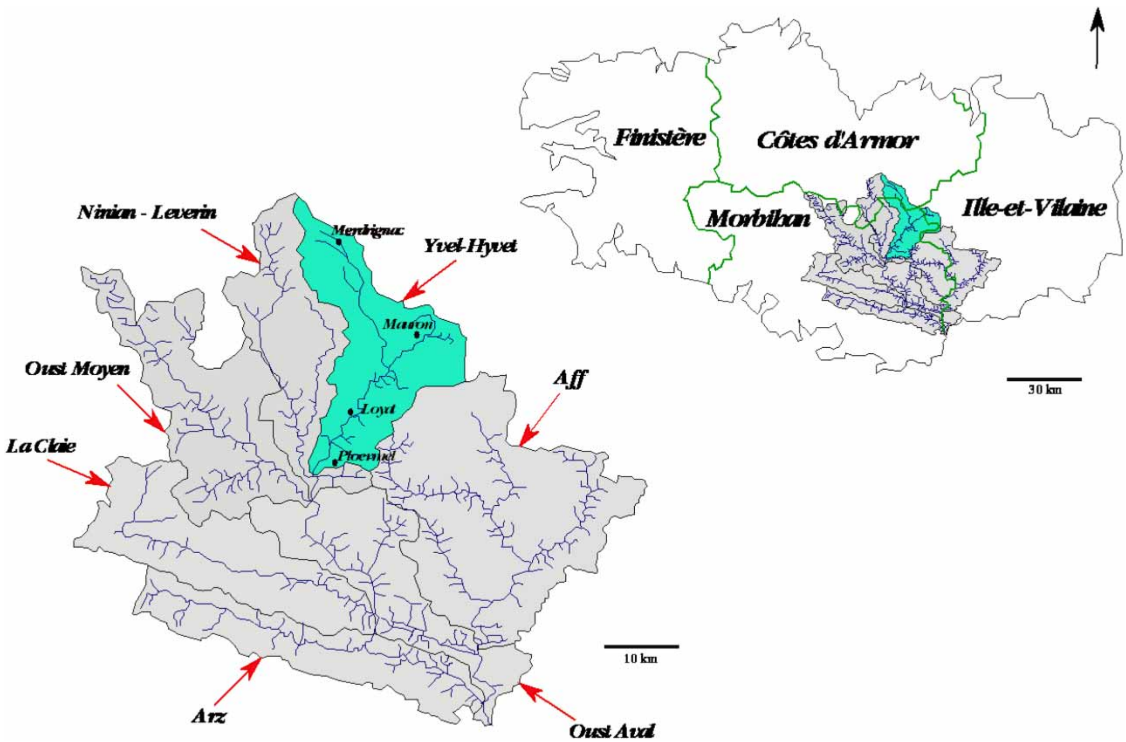

Fig. 1. Location of the Yvel-Hyvet drainage basin in the Grand Bassin de l'Oust and Brittany.

Results

Construction of river quality standards for nitrogen in France and its river basin districts

The choice of a particular parameter depends on scientific knowledge of the effect of the parameter on the aquatic environment, how easily it can be measured, and the way it can be interpreted. This interpretation depends in turn on the political sphere, which establishes a causal link between the state of the parameter and the objectives accepted by society in terms of health and environmental quality.

River quality standards: a trade-off between the protection of drinking water and the environment. The nitrate threshold values differ according to the objectives of the regulations – health or environmental – and the institutions that produce them (see Figure 2). They change over time as scientific knowledge improves and depending on the objectives of the institutions responsible for water and environmental management. The World Health Organization (WHO) first established the threshold of 50 mg/L for nitrate in the 1960s on health grounds, as recommended in its first guidelines for drinking-water quality published in 1984. This value was retained in 1998 in Directive 98/83/EC, which distinguished between 50 mg/L for surface water and 100 mg/L for groundwater.

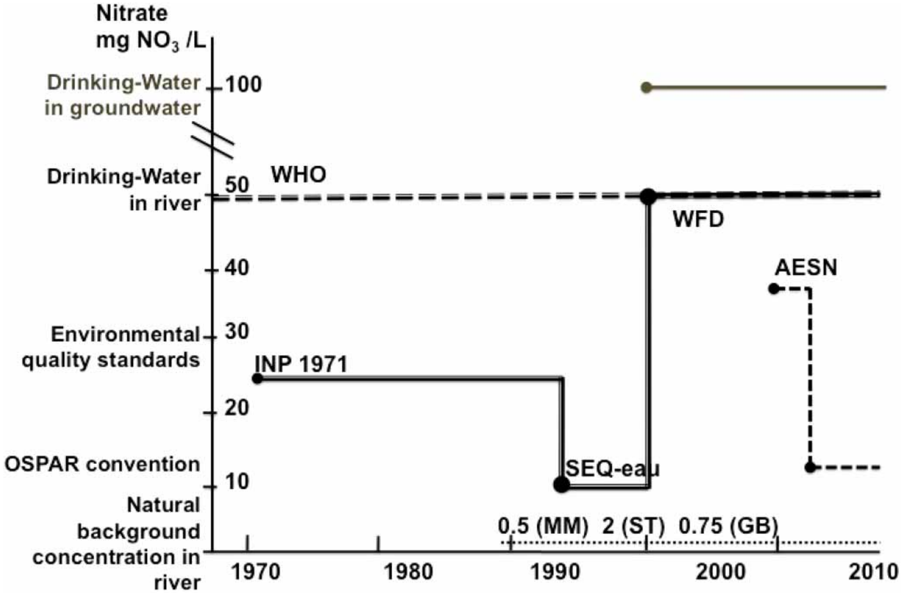

Fig. 2. The different threshold values for nitrate in France for surface water and groundwater. References for the natural background values: 0.5 (MM) (Meybeck & Helmer, 1989 *Palaeogeography, Palaeoclimatology, Palaeoecology* **75**, 283–309); 2 (ST) (Thibert, 1994 *Natural and anthropogenic exports of major ions and nutrients in the Seine basin.* PhD thesis, Université Paris VI, Paris); 0.75 (GB) (Billen *et al*., 2001 *Estuaries* **24**, 977–993).

The effects of nitrate concentrations on eutrophication became known only in the 1970s (Garnier & Billen, 2016). A water-quality evaluation system, the SEQ-eau, was drawn up following the 1992 Water Law, and introduced an objective of good ecological status for the very good and good classes, with nitrate concentration levels below 10 mg/L, while retaining the thresholds for moderate, poor and bad classes for specific uses (Carré *et al*., 2017). In this way, we can clearly see the tension between these two goals in how the standard is expressed, as it is based on a combination of the health concerns from the 1971 framework and a geochemical approach. The threshold values set for the very good and good classes correspond to the difference between the concentration of pollutants and the natural background established by geochemists, in other words, the naturally occurring concentration of a chemical element that serves as a benchmark (see Figure 2). However, nitrate is not considered as impairing the water's biological fitness and was not identified as constituting a deterioration of drinking water.

The Water Framework Directive (WFD) adopted in 2000 sets the objective of 'good status' for all waters, defining the parameters and the threshold values in the annexes. Nitrate is considered to be one of the general physicochemical elements accounting for biological conditions, although the threshold is much less stringent than that of the SEQ-eau, namely 50 mg/L instead of 10 mg/L for good ecological status (Table 1).

Differences in quality standards and nitrate monitoring between regions. The purpose of applying standards is to homogenize the rules for heterogeneous regions. Nevertheless, these standards and thresholds can be negotiated locally. Drawing up national guidelines has not prevented regional

Table 1. The nitrate threshold values (mg NO_3/L) for surface water in French guidelines.

1971		SEQ-eau 1995		WFD		WFD	
Simplified water quality framework		Water quality classes related to nitrate		Water status classes Min. of Environment Guidelines March 2009		Water status classes MEDDE Guidelines 2012	
Very good and good	<25 mg/L	Blue	<2 mg/L	Very good	10 mg/L	Very good	<10 mg/L
Acceptable	<50 mg/L	Green	<10 mg/L	Good	50 mg/L	Good	Between 10 and 50 mg/L
Poor	<80 mg/L	Yellow	<25 mg/L	Moderate	*	Bad	>50 mg/L
Bad	>80 mg/L	Orange	<50 mg/L	Poor	*		
		Red		Bad			

standards being set by water managers in response to changes in nitrate levels in their river basins. For example, in 1989 the Loire-Bretagne water agency (AELB) drew up a map of nitrates in the watercourses using personal thresholds such as: very good <3 mg/L, good from 3 to 10, moderate from 10 to 20, bad from 20 to 50, and very bad >50 mg/L.

Differences are also found in relation to operational monitoring of water bodies in danger of failing targets. In 2012 the Seine-Normandie water agency (AESN) observed that nitrates played a relatively small role in downgrading water quality due to the good/moderate threshold set at 50 mgNO_3/L by the WFD evaluation rules. The agency wished to show the ongoing deterioration of certain water bodies due to nitrate pollution. The new classes were then described as nitrate contamination. Using these values, 90 stations (instead of only 38) were identified as being problematic, with values of between 37.5 and 50 mg/L (AESN, 2012).

Awareness of the need for a threshold lower than 50 mg/L is also raised by France's ratification in 1997 of the Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention'), which commits it to a 50% reduction in the flux of nitrogen to the North Sea. A study of average nitrate concentrations in the Seine river basins in 2009 revealed an average concentration of 24 mg/L. The AESN thus set an average concentration target of 12 mg/L (i.e. 24/2). However, in view of the difference with the previous statutory objectives (50 mg/L and 37.5), it set an intermediary value of 18 mg/L at the entry to estuaries in order to obtain 12 mg/L in the sea. The French state then applied a stringent value of 18 mg/L to all zones discharging nitrate in France (decree of 5 March 2015).

Regional differences also emerge regarding the number of monitoring stations used by each water agency. For example, between 1971 and 1983 the AELB and AESN agencies followed a similar approach to setting up monitoring stations, but between 1983 and 1991 they adopted different strategies on the major rivers and zones with strong human impact, the AESN having many more direct monitoring stations. Following the adoption of the SEQ-eau after 1995, the two agencies once again harmonized their approach, adopting a similar strategy (see Figure 3). Within the agencies, regional variability can be observed in the way nitrate measures are used, due to specific socio-economic and political factors, as described in the next section, Results in Brittany.

Today, in all European countries 'the water resource monitoring used for Nitrates Directive reporting is aligned with the type of water resource monitoring required in the WFD, with its 'monitoring' network (long-term monitoring representative of all water bodies) and its 'operational' network (monitoring for 6 years specific to the parameters causing poor environmental status)' (Gault *et al.*, 2015).

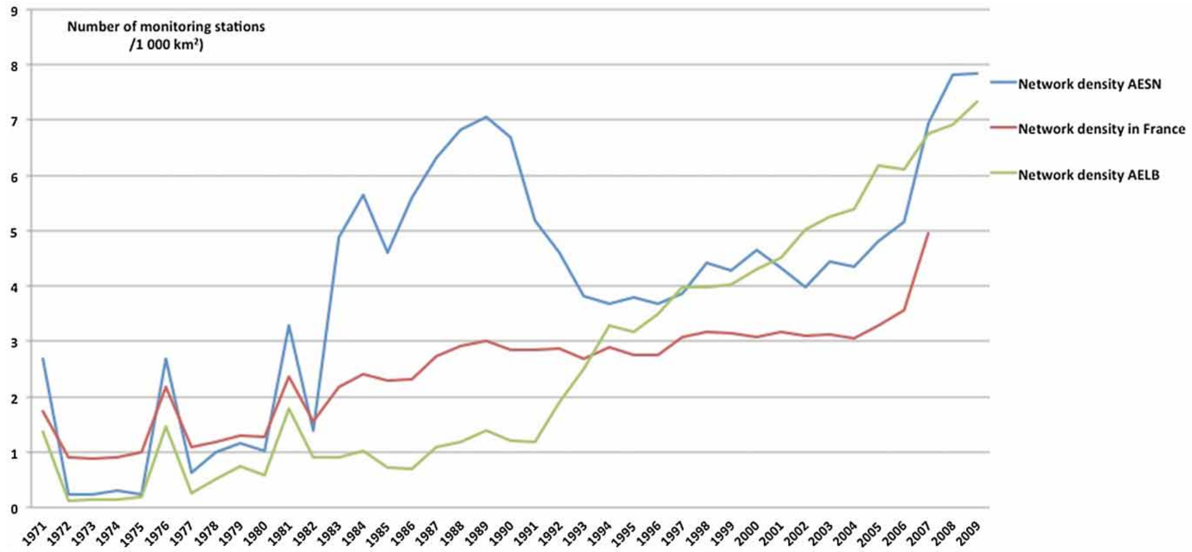

Fig. 3. Changes in monitoring networks' density (number of monitoring stations/1,000 km^2) in France, Seine-Normandie (AESN) and Loire-Bretagne (AELB) water agencies from 1971 to 2009 (Chemlal & Meybeck, 2015).

Results in Brittany

The weight of the political sphere on the implementation of standards and monitoring. Protection of surface-water quality is an issue of particular importance in Brittany in that 75% of drinking water comes from surface water, with a threshold of 50 mg/L instead of 100, in contrast to the rest of the country (Fleury & Guyomarch, 2003).

In the early 1990s, in response to the demands of environmental organizations and to the EU's criticisms of France, regional elected representatives proposed setting up a completely novel program in about 10 river basins, the BEP programs, which is unique in France, as water does not strictly come within the Regional Council's remit.

Through the BEP programs, areas were identified where the nitrate level in drinking water exceeded the 50 mg/L threshold. Other areas were included following the involvement of local elected representatives who saw the BEP programs as the lever for action they needed to prevent the closure of their drinking-water intake. Finally, the program also identified river basins with or without structures for managing and coordinating field actions locally. Until then, these local structures, composed essentially of elected representatives, relied chiefly on palliative solutions to maintain abstraction points; for example, mixing water from different sources in order to comply with QS, or improving denitrification processes at drinking-water production plants. These short-term solutions required heavy financial investment with no tangible effect on raw water quality. The objective of the BEP program was to achieve the most efficient results by identifying precisely the sources of pollution and the people who should be involved.

Setting up monitoring networks: state-of-the-art knowledge to protect drinking-water abstraction. Local knowledge was initially based on currently available data, such as the drinking-water producers' own monitoring on drinking-water intake. However, this was insufficient to identify the sources of pollution, and more information was needed about the overall activities in the basin and their impact on the environment. To this end, research organizations specialized in analyzing phenomena of the transfer of pollutants to water were called in, together with agronomy and development specialists in the Chamber of Agriculture. This shared competence provided the structure for the first water-quality analysis campaigns. The main parameter selected in relation to the risk to drinking-water supply was nitrate. Setting up a specific water-quality monitoring network at the river-basin level thus involved putting together different techniques, before finally producing a suitable tool for the BEP programs to assess the real problems of quality at a sufficiently fine scale.

> '*Getting a detailed view of the problem is very, very important, and to do so we carried out analyses at every stream junction point. We identified the most polluted areas (…); we monitored the classic physicochemical parameters, with particular emphasis on nitrate and gradually included additional pesticide analyses. The aim at the time was to cover almost the whole region with monitoring stations, almost at the level of the agricultural parcel*' (Technical manager of water-quality monitoring, GBO, 2014).

Up to the end of the 1990s, the data from this precise survey of pollution met three objectives: first, to acquire significant knowledge of nitrate pollution in order to estimate its effect on streams; second, to evaluate the direct impact of all sources of pollution on raw water quality; and third, to use this local knowledge to gain the agreement of local policy-makers and farmers for action on the ground.

This precise survey of pollution was possible due to the tight network of monitoring stations set up on the basis of the impact of nitrate on stream functioning. On the Yvel-Hyvet basin, samples of nitrate were taken monthly at 70 points along a 60 km stretch.

> '*We looked for concentrations of nitrate almost at the parcel level. There are sub-basins with streams 5 km long, with ten or fifteen measurement points. We had points at every confluence. We had very good knowledge of the area, and the aim was to know where the problems were and also what the results were. We didn't use the other networks much; we didn't even bother with them. In fact, we created our own network, without looking at what was nearby*' (Technical manager of water-quality monitoring, GBO, 2014).

The objective measurement at the river-basin scale became the key element to mobilize farmers and local officials. Brittany is an important livestock production region, and agriculture and the agri-food industry wield considerable power in the local economy. This can explain why the BEP actions targeting farming practices initially met with strong local opposition and why the changes put forward in the Nitrates Directive were not immediately applied. Setting up a specific water-quality monitoring network based on local expertise thus served to raise awareness of the problem of nitrate pollution and the need for action.

Comprehensive knowledge of where thresholds were exceeded also helped refine the diagnoses before launching the operational action at the start of the 2000s. The geographical scope of the contracts was extended, with about 40 Breton river basins included in the action plan and water-quality monitoring program. Thanks to the data obtained from these local monitoring networks, interventions at parcel and farm levels could then focus on the sectors contributing most to nitrogen input.

These developments show how monitoring had two consecutive aims. Between 1993 and 2000, water-quality monitoring at the river-basin level constituted a *knowledge network*, highlighting a regional public-health issue and justifying the obligations of the Nitrates Directive. Proximity between the pollution sources and the monitoring station was strengthened, with close monitoring of the areas where action was scheduled (upstream and downstream of agricultural parcels). By contrast, areas diagnosed as non-priority were no longer monitored. In the early 2000s, the status of this local knowledge changed as a result of the direct causal link between the monitoring data and the action. Thus, the knowledge network became *an operational network*, with close monitoring of actions.

Changes in political arbitration: from protection of the drinking water resource to WFD reporting. While nitrate levels showed a clear downward trend in terms of the threshold for drinking water at the beginning of the 2000s, concentrations reversing below 50 mg/L, the reduction was deemed insufficient in view of the amount of public money invested. This was the view expressed by the Court of Auditors in February 2002 and by the Regional Council of Brittany. New regional contracts were introduced (2007–2013), extending the scope to include local authorities and households. Interventions that had previously targeted the sectors considered to contribute most to the problem (agriculture, livestock production and the agri-food industry) were replaced by action at the scale of the whole river basin, including a broader section of the population and a wider range of issues. Moreover, the contracts no longer focused only on nitrate and pesticides for the protection of drinking-water sources, but also aimed to achieve the good status of surface-water bodies, according to the WFD.

> '*The BEP programs only involved two issues, nitrate and pesticides. In fact, it's the WFD that broadened the field. It's because of the WFD that we now cover an area up to the sea, that we've extended the areas. For the people working on the ground, who sometimes have very detailed knowledge of small areas, the issues they now work on have grown and they'll have to manage new areas that are bigger and unknown*' (Coordinator of the SAGE Vilaine, 2014).

In this new approach, the status of nitrate changed completely, from an indicator of massive non-point pollution affecting the production of drinking water, to one parameter amongst others to be monitored, resulting in a form of 'normalization of non-point source pollution' (Becerra & Roussary, 2008). Following the observation that the rates of concentration had decreased since the early 2000s, this parameter was no longer given priority in action programs. Now considered as an ordinary risk for drinking water, nitrate is included with other parameters, notably phosphorus, as a risk factor of degradation of the aquatic environment (eutrophication, algal bloom).

> '*The issue of phosphorus came later. Up to 2008, it was nitrate and then came phosphorus. It didn't exist before, and you can see that nitrate, it got put last, it wasn't a priority anymore. With the restoration of rivers, there perhaps won't be results straight away, but it should have some influence in decreasing nitrate; we'll surely gain a few milligrams*' (Technical manager of water-quality monitoring, GBO, 2014).

In this way, the monitoring programs were revised to adapt to these changes and to the reporting obligations of the WFD. In the Yvel-Hyvet basin, monitoring phosphorus and the organisms and microorganisms living in water environments became as important as monitoring nitrate when prioritizing local actions. The measurement protocol has also changed considerably, with a significant drop in the number of sampling points. Priorities for intervention are no longer determined by sub-river basin but at the scale of the water body over a much larger area. The monitoring stations that have been removed are those in the sub-basins with stable or good status. Only those on the main watercourse have been retained, at the confluence with a sub-basin to ensure a representative picture of the state of each water body. In the Yvel-Hyvet basin, the number of monitoring points dropped from about 60 at the start of the BEP programs (knowledge network) to 40 in 2008 (operational network), and then to about 12 scheduled in 2016 (see Figure 4 and Table 2).

The search for a direct link between the positioning of the monitoring station and the sources of pollution no longer appears in the new contracts. But while nitrate has tended to lose its role as a warning signal to trigger action, it remains one of the most widely monitored parameters in the Breton river basins; this allows data to be compared and local trends in nitrate levels to be observed over time, with the aim of justifying the efforts that have been made and to provide local expertise when there is insufficient information, giving rise to new questions and putting unexplored issues on the political agenda. Thus, the approach to monitoring shifted in 2015 towards establishing a reference state of the quality of a watercourse and its change over time, for European reporting.

Discussion

It is important first to stress the negotiated character of a water quality standard. Water management is profoundly influenced by social attitudes that change according to the uses of the resource and the status

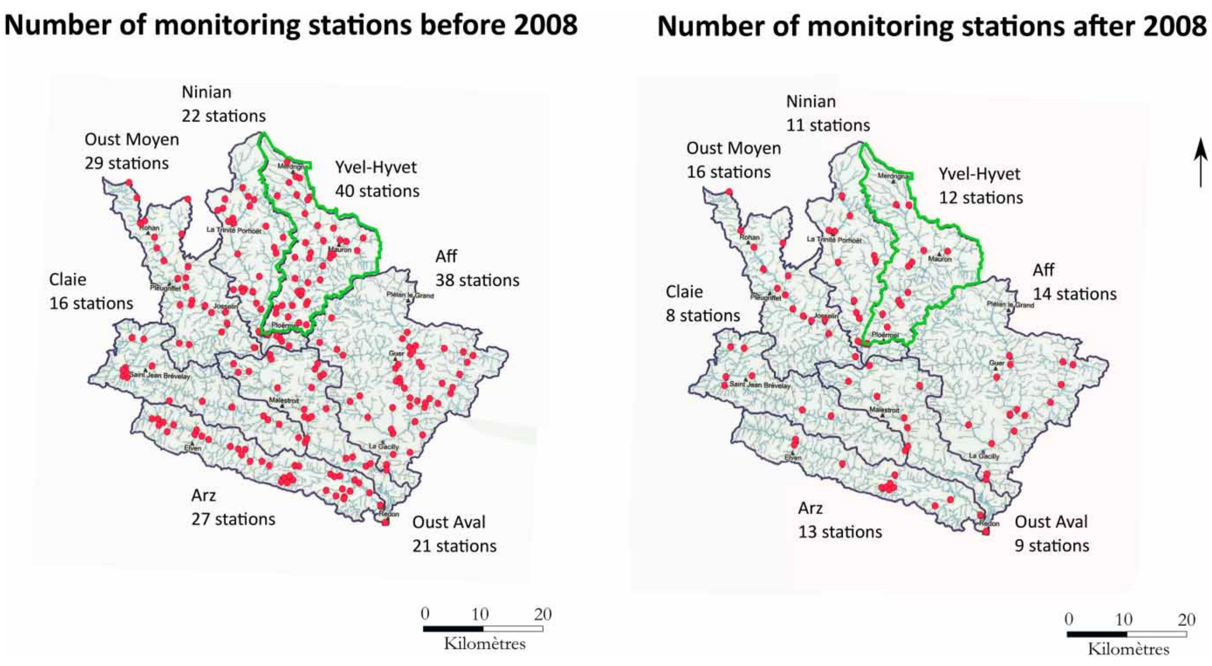

Fig. 4. The drop in the number of monitoring stations after 2008 following application of the WFD in the Yvel-Hyvet basin.

Table 2. The drop in the number of monitoring stations after 2008 following application of the WFD in the Yvel-Hyvet basin.

River basin	Number of monitoring stations before 2008	Number of monitoring stations after 2008
Aff	38	14
Arz	27	13
Claie	16	8
Ninian	22	11
Oust Aval	21	9
Oust Moyen	29	16
Yvel-Hyvet	40	12

of the aquatic environment. Standards are set at national and regional level, based on a trade-off between social and environmental factors. This process can clearly be seen in the complex formulation of QS for nitrate, with the juxtaposition of several threshold values within a single region at the same time (50, 40, 18, 12 mg/L). The ecological problems seen as action issues cannot thus be reduced to supposedly objective scientific and technical problems. The use of standards and monitoring data to initiate action may clash with the way they are interpreted locally.

Have water quality standards led to the expression of a collective regional problem and the mobilization of stakeholders?

Turning the regional problem of drinking-water protection in Brittany into a political issue led to a commitment to action by all the stakeholders, including farmers. It also brought about the convergence of water policies and agricultural policies, although the latter are highly institutionalized and their tools not easily transferable (Barataud *et al.,* 2013).

Nitrate was chosen as the parameter embodying watercourse pollution and the generator of a complex problem involving a wide range of regional players, including industrial firms (waste treatment), municipalities (upgrading sewage-treatment plants), and farmers (non-point source pollution). For farmers and industrial firms, the diagnoses and action plans form part of a broader context than just the river basin; for farmers, this includes the farm, fluctuations of the market for their produce, and the instability of national and European aid.

In the French context of regional water policy drawn up by elected representatives, the state, non-profit organizations, and economic stakeholders, the Breton case shows the emergence of a kind of regional adaptive co-management. Here, rather than Europe and state departments, it is the regional elected officers who develop measures that are both complementary and alternative. The state has recognized this regional institutionalization and in 2017 it granted the Regional Council of Brittany the authority to coordinate and manage water policies.

Referring to the different views of management presented in the article by Whaley & Weatherhead (2016), we can observe several of the mechanisms through which the process of co-management evolves, such as the setting up of flexible institutions that operate within and across scales of organization (creation of structures such as the GBO to make diagnoses for each sub-basin and to initiate actions with farmers), and the importance of social learning based on dialogue between scientists, managers, policymakers and farmers, whereby locally produced data serve to draw attention to and highlight the relationship between farming practices and nitrate pollution, and initiate action.

Has monitoring surface-water status effectively given a signal to trigger action?

All the people we met in Brittany saw that the standard and the exceeding of the threshold value provided a credible signal of water-quality degradation. And yet, explaining the process was not enough to initiate collective action. Setting up monitoring stations at the outlet of small river basins did indeed enable a connection between exceeding threshold value and specific inputs in the basin, and gave the basin structures the legitimacy to oblige the farmers concerned to act to limit the discharge. However, this did not happen until exceeding the threshold was seen as a political issue for Brittany and when the threshold value of 50 mg/L was identified as a realistic target for farmers and drinking-water producers. Monitoring data no longer served only to show the reality of the situation, but also and above all to construct a collectively desirable reality. Local and regional policymakers then acted to reduce nitrate discharges by enforcing regulations to improve effluent treatment from sewage-treatment plants and to protect the production of drinking water by changing farming practices, using the operational monitoring network to impose the means indicated by the Nitrates Directive.

It is undoubtedly here that the BEP programs were most innovative. Water management methods in France have been notably curative, with sewage-treatment plants financed by public investment and moving economic activities, including agricultural, to less vulnerable areas. Implementation of the BEP programs emerged from a standardization of expertise procedures taking specific local factors into account. The possibility of changing practices and altering the agricultural system was raised. Actions were developed with the farmers involved from the start of the diagnostic phase, and their expertise was used, rather than just their formal adherence.

We therefore need to look back at what made the BEP programs successful, even if their success was restricted to the protection of drinking water and did not reduce nitrate concentration to the levels imposed by current regulations to obtain good functioning of the aquatic environment. It is important to highlight the time needed to set up mechanisms; it took the GBO 10 years to obtain its own data and to build up a relationship of trust with farmers. More time was needed for the learning phase, using the technical and human means accorded by the BEP programs up to the end of the 2010s. From this date, the means have been severely reduced, weakening the links between farmers and the technicians who proposed actions. Finally, actions that had been undertaken systematically are now carried out essentially on a voluntary basis.

Have standards and monitoring been effective preventive management tools?

In recent years, data from monitoring have tended to lose their mobilizing capacity and role of alarm signal, as stakeholders consider that the nitrate problem has been resolved. This can be seen in the suspension of proactive measures to reduce agricultural nitrate input, as well as in the closure of a large number of monitoring stations in the operational network, even though it is well known that it is very difficult to identify the origin of pollution with this type of measure, particularly for non-point source pollution such as nitrate, and to target the necessary actions (Lequien *et al*., 2016).

The problem of eutrophication in bays is not (yet?) one that affects residents in the upstream basins, particularly as, up to now, river water quality concerned mainly drinking water. The degradation of the drinking-water resource is clearly a problem for Brittany, whereas algal bloom is much less so, if at all. The OSPAR convention lowered the level of nitrate concentration, with the aim of reducing the impact of outflow to the sea (algal bloom). This has been met with incomprehension and inaction at local and regional level, and the conceptual shift from thinking about ‘humans and nature’ to thinking about ‘humans in nature’ (Folke, 2006) has not happened. The universality of the new values (18 mg/L, 12 mg/L) does not correspond to local situations, and its performative dimension, involving a sense of the relationship between humans and the environment, is not perceived by all the local inhabitants.

Finally, the volatility of water or agricultural policy tools (QS thresholds, types of aid, recommended actions) prevents the use of consistent instruments that would encourage farmers to reduce nitrate levels. This time, in order to reduce concentration levels in order to limit coastal eutrophication, the aim would be to modify fundamentally the agricultural model. The people we met observed that the BEP programs led to adaptation of practices rather than a change in the model, most farmers remaining attached to a more intensive form of production. However, so far scientists and technicians have not been able to help them to find profitable ways of attaining the 12 mg/L of nitrate in the estuaries, without fundamentally altering their production system.

Conclusion

The establishment of QS is the result of political arbitrage between economic growth, health protection and resource preservation. It takes place at several levels, from the European level in the directives, the national level in their transposition and to the regional level where the water actors make adjustments that suit them.

Then, establishing norms is effective only if water managers decide to monitor and use the data to act. However, the Breton example, and it is far from being the only one, shows that one can choose not to see the pollution, by closing a drinking-water catchment, and generally with it the monitoring station, to connect with a neighboring drinking-water system.

Today, water agencies are trying to limit the number of stations to reduce their operating costs. If operational stations are closed, once the current pollution threshold is reached, it becomes very complicated to explain to a farmer that he must make new efforts to achieve a new quality objective, specifically to deal with a problem that he does not see as such.

Nevertheless, new regulations are possible that combine the quality of the water resource with the development of the territories. In recent years, the management structure in charge of the drinking-water production of Rennes Metropole has promoted the labeling of its drinking-water catchments in connection with the farmers who feed its school canteens. The quality of the rivers then becomes an element of the quality of agricultural production and its economic model, while Rennes Metropole ensures a sustainable agricultural activity. In this way, water policies are linked to other policies, such as agricultural policies, requiring specific work with the other regional players.

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