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Evaluation of Water Framework Directive metrics to analyse trends in water quality in the Netherlands

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ABSTRACT

The Water Framework Directive (WFD), implemented in 2000, is the major policy instrument for water quality in the European Union. Its main aim is to homogenise and standardise water quality assessments in all Member States, stimulate water quality improvement and contribute to the management of transboundary water problems. Surface water quality descriptions are a crucial part of the WFD. The first WFD assessment was presented in 2009 and in 2014 a second set of results were available, allowing comparison of the status between both years. The main issue for policymakers is whether the quality has changed over the past years. In this study, two methods are evaluated to examine the differences in surface water quality. The WFD method uses the differences in the percentage of water bodies with a good quality for comparing between both assessments. The time-series method uses the WFD metrics to calculate water quality with all available monitoring data, aggregated to grid cells. The conclusion concerning the WFD method is that the two assessment reports of 2009 and 2014 are too dissimilar in method and standards and therefore not suitable to evaluate changes over time. The time-series method showed a small improvement for phytoplankton and macrophytes and no improvement for benthic invertebrates.

1. Introduction

In many countries, the chemical quality of surface waters is insufficient due to the emissions of organic pollutants, nutrients, heavy metals and toxic substances from households, agriculture and industry (EEA, 2010; MA, 2005; OECD, 2012). Biological quality is also affected by hydro morphological changes, such as habitat composition, flow dynamics, shading or the availability of food sources (Borja et al., 2005; Hering et al., 2013; Jeppesen et al., 2005; Marzin et al., 2013). Many different systems have been developed to describe surface water quality (Abbasi and Abbasi, 2012; Leeuwen et al., 2012; Ott, 1978; Srebotnjak et al., 2012; Verdonschot et al., 2012). Most systems evaluate the quality of nutrients and organic pollutants, some include toxic pollutants. Other systems are based on the abundance of plants or benthic invertebrate species (Birk et al., 2012; Keizer-Vlek et al., 2012; Verdonschot, 2012).

In EU Member States, the Water Framework Directive (WFD) is the major policy instrument for surface water quality (EC, 2000). The WFD assessment includes a classification of the ecological status of surface waters on a scale from high (effectively pristine) to bad, including intermediate steps of good, moderate and poor; assessment of toxic pollutants results

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in two classes, good and not good. Ecological quality is the most important indicator and primarily concerns biological quality, which is based on the four biological quality elements (BQEs) of phytoplankton, benthic invertebrates, macrophytes and fish. The national survey of ecological quality is the result of several underlying agreements on how to aggregate and classify the monitoring data.

The first aspect of the ecological assessment is the spatial assignation of assessment units of the surface waters (the water bodies). Spatial characteristics are classified into different typologies of rivers, lakes, estuaries and coastal waters; in the Netherlands a classification is used into 50 different types of surface water. The metrics for the BQEs and the standards for the physico-chemical quality are defined for each water type. Another aspect is the option to define a lower standard for heavily modified or artificial water bodies; the good ecological potential (GEP), for a BQE or a physico-chemical parameter. This option can be used for water bodies where a good condition can only be achieved with disproportionate damage to other functions. A number of the underlying quality elements and the final indicator are aggregated from their components with the 'one out, all out' principle; when one component does not meet the standard, the final indicator or the quality element also does not meet the standard.

This total set of indicators and spatial characteristics makes the WFD a complete water quality assessment with many different elements, but also complex and inflexible (Hering et al., 2010; Reyjol et al., 2014). The 'one out, all out' principle used in the aggregated indicator is in line with the precautionary principle and will provide sufficient protection. It also results in an aggregated indicator that mostly masks any improvement, because in most cases there are one or more substances that do not meet the standard. Chemical quality and quality of river-basin-specific pollutants are determined by many substances, but with the 'one out, all out' principle, it does not make a difference for the aggregated indicator how many substances failed to achieve the standard. Another critique is the spatial classification of water bodies; small surface waters are not designated as a water body and therefore not included in the assessment (Biggs et al., 2014). Small waters are a critical and vulnerable part of the freshwater landscape, especially in the Netherlands where ditches with their long combined lengths are important for national biodiversity. The option to define GEP for heavily modified water bodies results in different standards for water bodies of the same water type, which makes comparison between water bodies or regions difficult.

The first results of the WFD were presented in 2009 (EEA, 2012; VenW et al., 2009). The Member States with the worst water quality were Belgium, the Netherlands, Luxembourg and Germany. The results for the Netherlands were based on the first description of the assessment method for BQEs (Evers and Knoben, 2007; Molen and Pot, 2007a,b). In 2014 new results of the WFD assessment became available, but certain metrics and some standards in the WFD assessment having been improved (Evers et al., 2012; Molen et al., 2012). This improvement was a result of the evaluation of the first assessment and part of the intercalibration to unify the BQEs in the EU Member States (Birk et al., 2012, 2013). A consequence of this intercalibration is that the results of 2009 and the recent results cannot be compared. For the same reason, the WFD results cannot be used for trend analysis, despite the long series of monitoring results which sometimes are available.

The results of the WFD assessment with the data on 2009–2013 were published on relevant websites and in reports for policymakers and the general public (CBS et al., 2010; PBL, 2014). Policymakers use these results to compare between different years and to claim an improvement in water quality. The question is whether such improvement is the result of a change in method or is an actual improvement in the environment.

In this report the 2014 results of the WFD are presented and compared with those on 2009. Two methods are used to calculate the differences over time. The first method, the WFD method, uses the percentage of good quality water bodies as a means of comparison. In the second method, the time-series method, the metrics of the BQEs are applied to all available monitoring data. With the time-series method, we present time series of biological quality over 20 years. These time series are related to the WFD results as they are calculated with the same metrics, but are different in their spatial aggregation and standards. These differences are necessary as the WFD assessments cannot be duplicated in the same way on a national scale. From the study we conclude that, under both methods, the water quality with respect to phytoplankton and macrophytes shows improvement. The water quality with respect to benthic invertebrates appears to improve based on WFD results, but is unchanging under the time-series method.

2. Materials and methods

The WFD assessment results for 2009 and 2014 were received from the 'Informatiehuis Water' (http://www.waterkwaliteitsportaal.nl/ downloaded 14 June 2014), the organisation that collects the data from water boards and the Dutch Ministry of Infrastructure and the Environment. For each water body, these data files contain the assessments for the underlying substances, parameters and BQEs, and the aggregated and final indicators of the WFD. Missing information has been indicated by 'no data' and 'not relevant'; this last category applies to situations where the specified indicator was not applicable for a particular water type, such as phytoplankton in running water. Both 2009 and 2014 were compared to explore the changes in water quality. The concentration of the parameters and the EQR of the BQEs were not available for the intervening years, therefore only the assessments of 2009 and 2014 were used in the trend analysis.

To explore the changes in biological quality of surface waters over a period of 20 years, the database of the Limnodata Neerlandica, www.limnodata.nl was used. This database contains all biological data collected by the water boards and the Ministry. The Ecological Quality Ratio (EQR) can be calculated for each monitoring sample of phytoplankton, benthic