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FOUNDATION
FOR APPLIED WATER RESEARCH

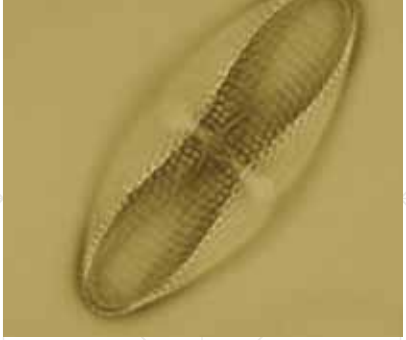
HYDROCHIP, MONITORING WATER QUALITY USING DNA

2017
23B

Life

THE PROJECT FRAMEWORK

The Hydrochip project was developed as part of the EU Life+ program between 2012 to 2017. Life+ is the EU's funding platform for the promotion of the environment. Hoogheemraadschap Hollands Noorderkwartier, STOWA, TNO, Vitens and Waternet are the five collaborative project partners.



REASON FOR THE PROJECT

Water managers in the Netherlands and across the European Union are responsible for improving and maintaining the water quality of lakes, rivers, streams and locks. Adequate surface water quality is essential for the health of aquatic ecosystems and for maintaining the multiple socio-economic functions the water provides, which include, fishing, recreation and drinking water production. Water quality in the Netherlands is under threat in many places due to many functions that the water system provides. The current and most significant threats are the result of a large supply of nutrients to the water, strictly monitored water levels and hard structural interfaces where the water meets land.
It is possible to assess the status of the water quality by determining the plants and animals present. It is then possible to gauge whether the measures chosen to improve the water quality are effective.
Diatoms are a common type of algae that provide information about the quality of the water. By extracting and analysing the DNA from the water it becomes possible to determine the species and their abundance quickly and cheaply. The information can be easily used to determine the nutrient levels of the water which is a good measure of the ecological water quality. The Hydrochip project is a collaboration project with five partners.

HOW THE HYDROCHIP WORKS

The classical way of analyzing diatoms and thus obtaining an image of water quality is via light microscopy. The species and numbers present are determined by specialists. The idea behind Hydrochip is that DNA from a water sample can be used to determine the microorganisms present, such as diatoms, thereby determining the food richness or trophic level of the water. The chip is made by placing specific pieces of DNA of selected algae species between a glass slide. Because DNA from the water samples can bind to these fragments, a pattern of DNA spots occurs on the chip.

The analysis of surface water samples using the Hydrochip proceeds through a series of steps summarised in Figure 1. The Hydrochip principle is also displayed visually in a video (follow the link provided).

The Hydrochip can handle many samples from various locations quickly and cheaply. This enables water administrators to map the state of the water and determine the suitability of the current management measures. The information can be used to report on the ecological state and to modify measures where necessary. For samples where the Hydrochip cannot give a clear result or where specific information is required about abundance or specific types of organisms, the classical microscopic method can be applied.

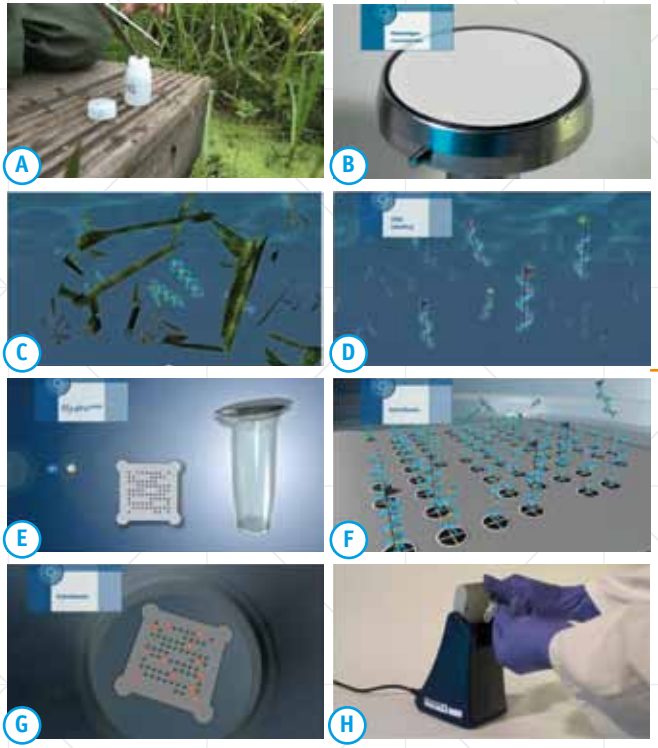


FIGURE 1.
Shows the steps used when applying the Hydrochip. A reed stalk is sampled and used for the analysis of algae **(A)**.The sample is concentrated by filtration **(B)**. The diatoms are broken and the DNA is extracted **(C)**. The DNA is made visible by affixing labels **(D)**. Schematic representation of the Hydrochip as found on the bottom of a small plastic reaction vessel **(E)**. Binding of labeled DNA, from a water sample, to the DNA on the surface of the Hydrochip **(F)**. Specific spots on the Hydrochip give a signal: this indicates the presence of the species in the sample **(G)**.The chip reader reads the result of the Hydrochip **(H)**.

DEVELOPMENT PROCESS OF THE HYDROCHIP

A comprehensive series of steps were taken whilst developing the Hydrochip. They are discussed individually below.

WATER SAMPLES

Water samples have been collected in different waters throughout the Netherlands. So-called 'growth' samples, such as reed stems and stones were analysed using a microscope to determine the occurrence of species and the species abundance of algae and diatoms within the samples.

DEVELOPMENT OF THE CHIP

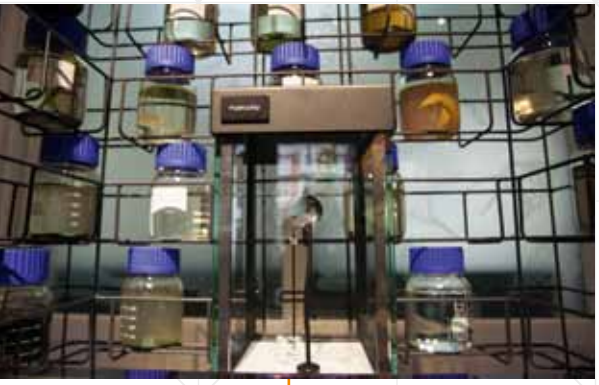
DNA has come from about 150 kinds of diatoms. These 150 species were chosen based on their appearance in the Netherlands and how indicative they are for a certain amount of nutrients in the water; from nutrient poor to very rich. The DNA of these species has been sourced from existing databases and via the cultivation of specific types of diatoms by extracting them from a water sample with a so-called micromanipulator. This latter method proved to be very labor intensive and for this reason a different approach has been chosen. The DNA of all organisms present in the sample were finally determined via the identification of the trophic level the species represents. All kinds of (micro) organisms, including diatoms, were used with this innovative method and were then used as a reference to support which types of organisms were indicative of each trophic level.

INTERNATIONAL APPLICATION OF THE HYDROCHIP

The Hydrochip was developed in the Netherlands, but could also be applied in other European countries. This is likely due to the prevalence of the selected types of diatoms in other countries in similar water systems.

PILOTING THE HYDROCHIP

The Hydrochip has been extensively analysed and tested under controlled laboratory conditions. The nutrient levels of all the water samples were determined based on a classical analysis method using a microscope and by means of the Hydrochip.
The results were then compared to test the quality of the Hydrochip.



The settup in Micropia in Amsterdam

COMMUNICATION ACTIVITIES

During the project, much attention was paid to communication with water managers and the larger public. The project has its own informative website and articles, presentations, workshops and a brochure have been created. Hydrochip also has an exhibition at Micropia, which is a popular part of the Natura Artis Magistra Museum in Amsterdam. Micropia museum allows its visitors to experience the invisible world of microorganisms first hand through interactive displays. The exhibit has received a wide audience, since the project opened in October, 2014.
Hydrochip was nominated for the water innovation award in 2013 and won the third prize in the Vernufteling in 2014.

OUTCOMES

The project partners intended to develop a new, DNA-based molecular technology with Hydrochip, which enables a fast, reliable and cost-effective assessment of the biodiversity and the ecological quality of surface waters. Hydrochip would therefore be an attractive alternative to labor-intensive, costly and complex microscopic monitoring techniques as a measurement method. The purpose of the LIFE+ project is to demonstrate the operation of the Hydrochip under practical conditions.

However, in practice, Hydrochip does not produce the distinctive results that are important for measuring and assessing the ecological quality of surface water. To improve reliability, one or more subsequent versions of Hydrochip should be developed and validated. This requires additional investments, while the outcome and hence the probability of success are very uncertain.

Additionally, Hydrochip has now been superseded by a competing technology known as Next Generation DNA Sequencing (NGS). Compared with Hydrochip, this technique is faster, less error-sensitive, has a broader scope (all types in surface water, from algae to fish) and is a more automated process. In recent years, the number of companies offering NGS services have risen and prices per sample are similar or even lower than Hydrochip.

The project partners find that despite the efforts and investments so far, the further development of Hydrochip is too risky. The consortium has decided to discontinue further development of the Hydrochip project for the reasons above. The Hydrochip project has had a very positive influence and has achieved several very important results. The project has contributed significantly to the potential for DNA monitoring for water managers. The change in the use of new water management techniques is slow and Hydrochip has provided the important first steps in this process. This has greatly increased acceptance and attention to innovative monitoring techniques, that make it possible to monitor water quality, whilst identifying the presence of certain species.

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MORE INFORMATION

For more information contact Bas van der Wal at STOWA (stowa@stowa.nl) or go to www.watermozaiek.nl.

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