dependent agriculture without a certain nutrient surplus will not be feasible, on the other hand be- cause the Dutch soil is loaded with nutrients from the past. That is why Deltares develops supplementary measures. These measures focus on the route between source and surface water. For instance, smart application of technology in the field of purification, storage and re-use. An example of such a measure is water cycle purification.

Water cycle purification: from drain to pumping station
Deltares performs research into the use of water purification in various phases of the water cycle. This includes purifying drains, purifying units near drain ends or even purification near pumping stations. Different kinds of purification techniques lead to water quality improvement as it stimulates attenuation and immobilization reactions. Deltares offers a unique combination of geochemical, ecological and hydrological expertise for future realization.

Another aspect is curative measures in the surface water body itself. These measures primarily reduce the effects of high nutrient concentrations. During this process, nutrients are sometimes removed from the surface water. Examples of these kind of measures are: covering up a eutrophic water bed with a clean layer to reduce nutrient mobilization from sediment to the water column or creating more beneficial ecological circumstances for water plants or predator fish breeding. Retention of nutrients will then be stimulated.

Nutrients from soil to sea
Clean water results in ecologically good ditches, streams, pools and lakes. The marine ecosystems also benefit. Of course, clean water is also nice to swim in or soil on. Despite all the useful efforts of the past decades, the nutrient concentrations in The Netherlands are still a problem when it comes to surface water quality. Therefore, it deserves our serious attention. We need expertise on hydrology, chemistry and ecology to solve this problem and deal with it. Deltares has this expertise. We have information on nutrient sources.

We also have a lot of experience on performing system analyses, on which nutrient transport routes are based. We study these insights to further expand our expertise. Deltares is familiar with the processes and performs studies to better quantify them. We use this expertise to develop models and monitoring concepts. We aim towards improving the water quality on a socially responsible manner. We concentrate not only on preventive measures, but also on curative measures focussing between source and surface water and curative measures in surface water itself.

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In The Netherlands, the high concentration of nitrogen and phosphate has an adverse affect on the quality of our surface water. The abundant growth of algae, water plants and reed is also a recurring problem in Summer. Furthermore, the discharge of nutrient-rich water into the sea is a real threat to the marine ecosystem. Unfortunately, the origin of all these nutrients often remains unclear.

The total nutrient concentration in surface water is determined by a range of sources, transport routes and chemical or biological processes. Nutrient cycles at a river basin level are therefore very complex. To come up with solutions to improve the water quality it is very important to gain insight into the origin of the sources, their transportation time and what happens en route. In other words, we need knowledge, such as chemical and physical expertise on soil, groundwater and surface water and their interactions. Deltares has the expertise on this complete range of aspects, as is illustrated below.

Water quality and nutrients
Over the past decade, a lot has been done to improve our surface water quality. Almost all households are connected to the sewer or have individual wastewater treatment. Detergents are almost phosphate-free. Agriculture made a lot of progress reducing the manure surplus. However, in The Netherlands there are still a number of locations with poor water quality (see frame: water condition).

Nutrient sources
Agriculture is often regarded as the main culprit in cases of high nutrient concentrations in surface water. Large amounts of nitrogen and phosphate have ended up in the environment after many years of over fertilizing agricultural land. Even now, surface water cannot handle the fertilization surplus. However, agriculture is not always responsible for the high nutrient concentrations. In peat areas, mineralisation of organic...
Water condition
According to the annual progress report of the Netherlands Environmental Assessment Agency on the realization of environmental targets, nutrients are a limiting factor in achieving the goals for ecological water quality (Good Ecological Potential (GEP)) as set by the European Water Framework Directive. Because of too high nutrient concentrations, 60 to 80% of water bodies in all Dutch river basins have a ‘moderate’ or ‘inadequate’ status. A ‘poor’ ecological condition applies to 10 to 20% of the water bodies. Only 1% of the water bodies in the Rhine Delta have good ecological condition. In the Scheldt basin, none of the water bodies complies with the standard set for phosphorus. For the Rhine basin, 37% of the water bodies meet the standards. For total nitrogen, similar percentages are found for the Scheldt basin 2% and for the Ems Basin 45%. These numbers give a clear indication of the problem.

Emission registration database
Deltares has a lot of expertise on quantifying nutrient sources. Commissioned by The Ministry of Transport, Public Works and Water Management, we manage the Emission Registration Database for surface water. The aim of the emission registration is to reach a consensus to determine a yearly dataset with univocal emission data. This dataset must comply with the following criteria: topicality, correctness, completeness, transparency, comparability, consistency and accuracy. By storing the information in one central database, we efficiently and effectively comply with national and international statutory obligations for reporting emission data. We work together with experts from Wageningen University on the subject of agricultural related sources.

Monitoring and modelling
To quantify nutrient transport routes in river basins, Deltares invests in new measurement techniques and model concepts. It is not only interesting to know how the systems works. We also want to gain more insight into the processes to be able to improve the situation. In other words: can we expect improvement when continuing the current policy? If yes, when? If not, what additional measures can best be taken?

Coupled models
Together with Alterra, Deltares is developing a new 3D model concept to simulate the nutrient transport in soil and groundwater. This model is a combination of the existing models ANIMO (unsaturated zone model of Alterra) and MT3D (saturated zone model used by Deltares). Another project for which we work together with Alterra is the project Monitoring River Basins. The project’s main objective is to quantify the effects of the manure policy on nutrient concentrations in surface water, on a river basin area level, by a combination of measuring and modelling. Existing high-resolution groundwater flow models, which are available for large parts of The Netherlands, can directly be used for water quality calculations.

Water quality
With the sophisticated models SOBEK and DELFT3D, many biological and chemical surface water processes can be simulated. These models are based on the water quantity models of SOBEK, DUFLOW, SIMONA or DELFT3D for modelling ditches, streams, lakes and coastal and transitional waters.

Effectiveness of measures
A lot of effort has been put in a new version of the Water Framework Directive Explorer. Water managers need an instrument to assess the effectiveness of measures meant to improve water quality and ecology. This assessment is important because of the implementation of the European Water Framework Directive. The WFD Explorer will be used by the water authorities in the Netherlands for development of the new river basin management plans. Deltares has also developed the Emission Module, a software program that couples emission data and water quality model applications. The Emission Module combines information on pollution sources and calculates the emission of substances to the surface water. Source information of national databases, such as the emission registration, or even measurements data can also be used.

New measurement techniques and new insights
Nutrient leaching from agricultural land to surface water shows a very dynamic behaviour in space and time. There is a distinct relation between the precipitation intensity and the nutrient concentration in surface water. Processes, such as overland or shallow subsurface flow, seem to contribute substantially to the total phosphate load. Short periods with high precipitation intensity can dominate the total phosphate load. Therefore, it is essential to measure at the right location and at the right time. These insights call for innovative measurement techniques. A classical monitoring strategy with one or two samples a month analysed in a laboratory will not be satisfactory. High resolution and time averaged field measurements offer a solution. Deltares is busy to operationalize these monitoring techniques for nutrients in river basins.

Example: the SorbiCell concept
SorbiCell is a smart passive sampling method to measure mean concentrations over longer periods. SorbiCell is a porous cartridge that “filters” pollutants from water passing the SorbiCell. It consists of a two-piece tube, the first part is filled with slowly soluble salt and the second part registers the nitrate of the water flowing trough. The amount of salt solution is a standard for the amount of water that flowed through “Sorbi”. Together with the volume of nitrate, this indicates the mean nitrate concentration of water that passed through the pipe.

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Figure: high frequency measurement series of phosphate in the outflow location of the Hupsel brook catchment. Arrows indicate the sampling times of the Water Board.

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