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Feasibility study: using $\delta^{18}O\text{-}PO_4$ to identify phosphate sourcesin Dutch surface waters - peat, manure,sewagetreatment plant or natural, nutrient-rich groundwater?

Introduction

High nutrient concentrations are in the Netherlands and most other European nations the biggest challenge to comply with the European water quality guidelines. The continuous application of manure and fertilizers by farmers has a strong impact on the phosphate concentrations in surface water systems. However, due to the complex behavior of phosphate in the environment, the extent of the contribution of manure and fertilizer application is most of the time hard to quantify. This is especially the case in areas with large natural phosphate pools, like peatlands or naturally phosphate-rich groundwater (Fig 1). Direct identification of the phosphate source(s) in eutrofied areas as the Netherlands will strongly contribute to a more sustainable water and soil management.

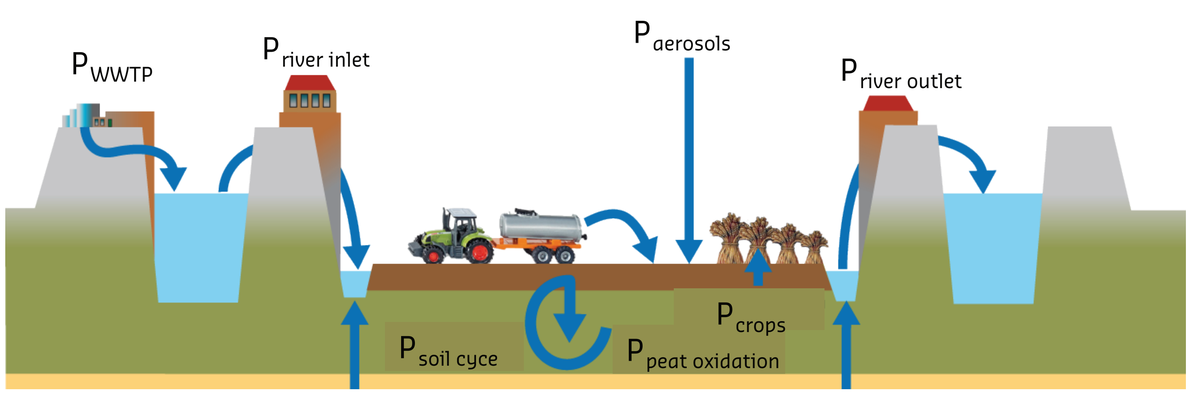

Fig 1 overview of phosphorus fluxes in a polder area.

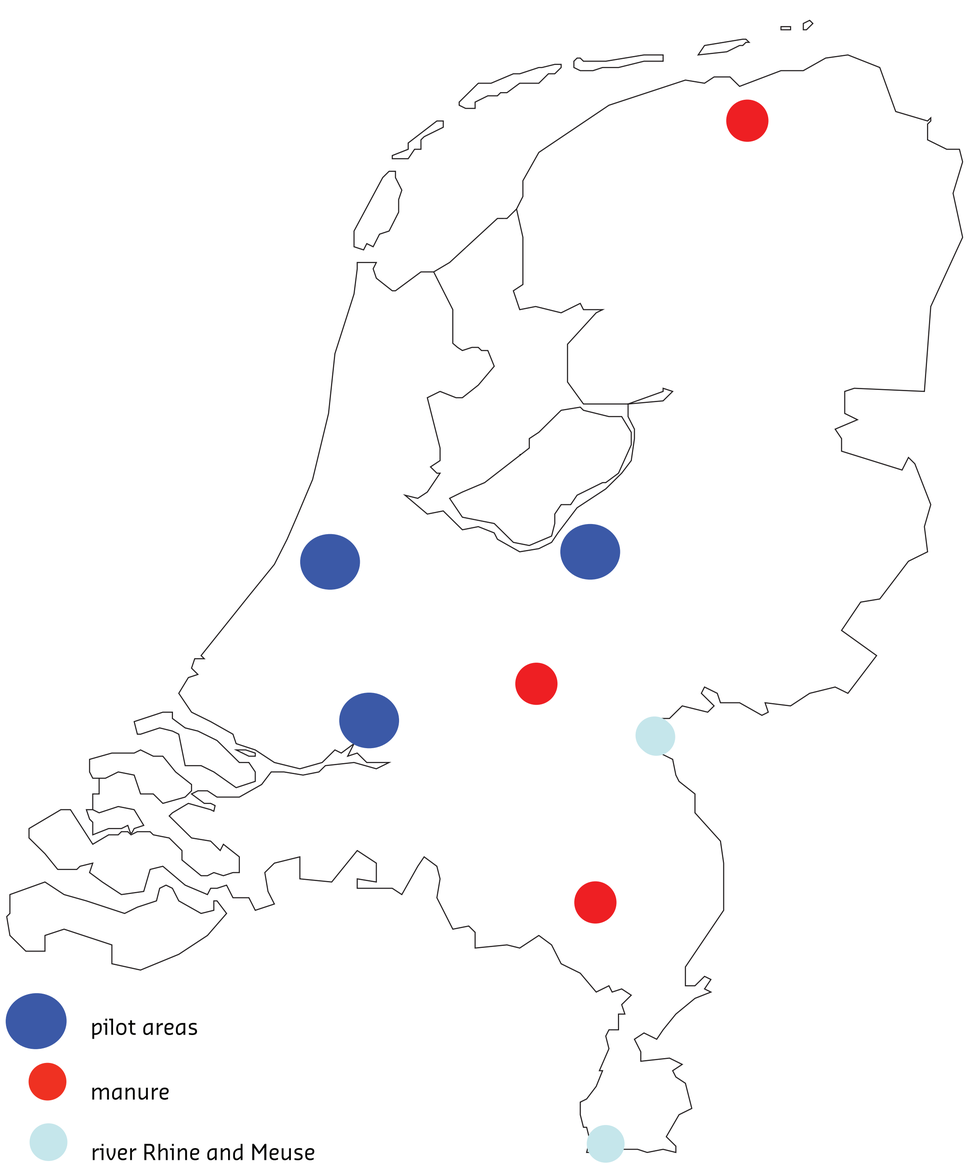

Fig. 2 sample locations.

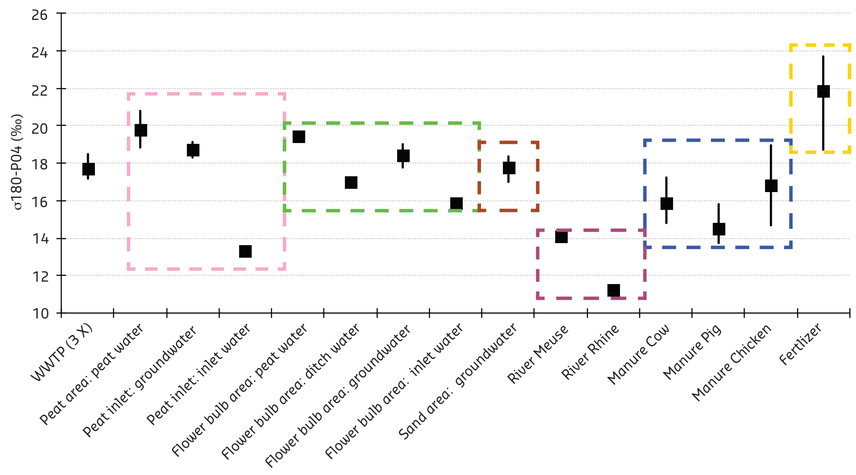

Fig 3 $\delta^{18}O\text{-}PO_4$ isotope ratios

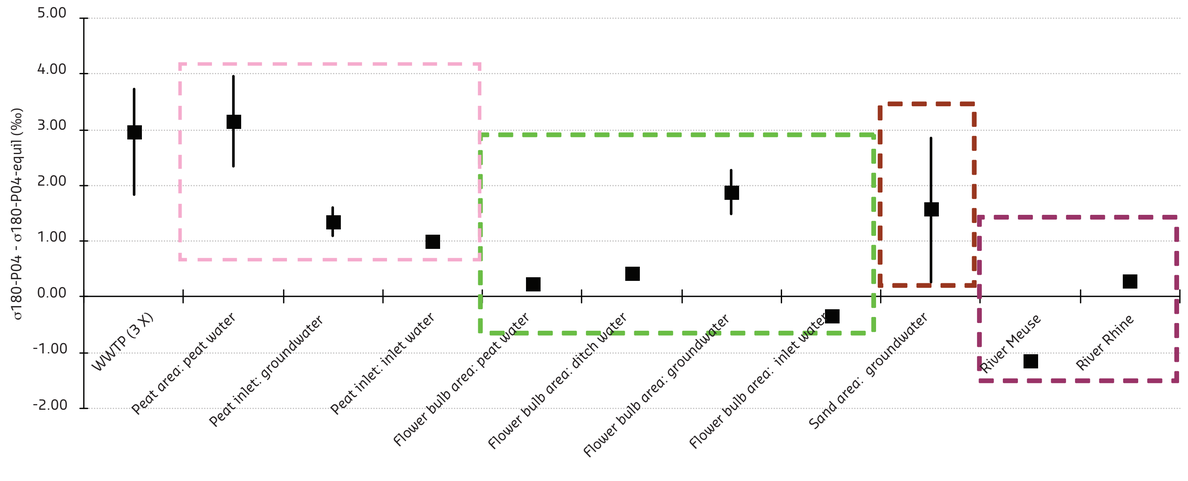

Fig. 4 equilibrium $\delta^{18}O\text{-}PO_4$ isotope ratios

The applicability of using $\delta^{18}O\text{-}PO_4$ isotope ratios for the recognition of phosphate sources in different geographical settings within the Netherlands is being investigated. In the first phase, 40 samples, representing different source materials(groundwater, peat water and sewage treatment plant from 3 pilot areas, manure, fertilizers, and large river systems),were collected and the $\delta^{18}O\text{-}PO_4$ isotopic ratio was determined (Fig 2). These samples are considered to be representative for their specific phosphate source.
The water equilibrium $\delta^{18}O\text{-}PO_4$ isotope ratios where calculated according to Longinelli&Nuti, 1973 (where T_w = temperature of the water):

The results from phase 1 suggest small but relevant isotopic differences between groundwater-peat water, and manure-fertilizers. River and inlet water have light $\delta^{18}O\text{-}PO_4$ (Fig 3 and 4).

$$\delta^{18}O\text{-}PO_4 equil = \left(\frac{111.4 - Tw}{4.3}\right) + \delta^{18}O\text{-}H_2O$$

Next, we will focus on the biogeochemical transition of the phosphate during the hydrologic pathway from manure/peat to pore water in the unsaturated zone, groundwater and surface water and the potential fractionation in the $\delta^{18}O\text{-}PO_4$ isotope ratios. We will also investigate whether or not the isotopic source signature can still be distinguished in the surface water system.
We will do this for the three pilot areas:
1. a peat area with dairy farming,
2. a flower bulb area with very intensive fertilization and
3. an agricultural area with low reactive sandy soil.

Reference:

Longinelli and Nuti, 1973: Revised phosphate-water isotopic temperature scale.
Earth and Planetary Science Letters 19: 373-376.

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