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Groundwater as a main input path of nutrients to a lake ecosystem - a case study from Germany

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Groundwater is often a neglected path in nutrient budgets of lake ecosystems. Nevertheless groundwater may be the most important path for eutrophication of surface water systems. This is shown for the case study of Lake Arendsee in Sachsen-Anhalt, Germany. Increasing phosphorous (P) concentrations of the lake water body during the last decades led to serious algae blooms (cyanobacteria) not only in summer times but also in spring and autumn periods. Calculations based on annual P net sedimentation and annual P outflow showed that a total external P load of about 2 t yr-1 is required to keep up high concentrations of about 200 μg of total P/l in the lake water body. To determine the sources of these P loads all input paths were investigated as there are:

• surface inflows (rivers, streams, ditches)
• wastewater (canalizations leading right into the lake, leakages out of the canalization system)
• wet and dry deposition on the lake surface
• groundwater inflow
• waterfowl

In contrast to groundwater most of these input paths are more or less easy to determine. Groundwater and associated nutrient inputs into a lake can either be calculated (when important information e. g. hydraulic conductivity is available) or measured. In both cases several difficulties come up: The size of the lake-groundwater-interface is usually large and spatial and temporal heterogeneities in the aquifer are difficult to take into account. This complicates calculations about the amounts of groundwater reaching the lake. Furthermore, high variability in nutrient concentrations sometimes requires a large number of measurements to calculate correct nutrient loads. These concentration differences may occur for example due to point sources of nutrient inputs into the aquifer. In addition the groundwater-lake-interface is a highly reactive zone so that nutrient concentrations measured in the catchment can be significantly different from those of the groundwater actually entering the lake.
A combination of both, calculations and measurements, led to consistent results of phosphorus loads of the groundwater into Lake Arendsee. It is concluded that groundwater inflow accounts for about 50 % of the overall P load to the lake. Nevertheless, to receive reliable data many problems still have to be solved and improvements need to be done. Techniques and applied data should be adapted to the conditions of the individual study site. The importance of such investigations could be shown in the case of Lake Arendsee.