Oxygen isotopic composition of bivalve skeletal aragonite and river water in a Dutch Rhine branch

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River Waal

The Waal is the largest brach of the Rhine in the Netherlands. It has a characteristic seasonal $\delta^{18}O$ profile. In summer $\delta^{18}O$ values can be as low as -10‰ (vs. SMOW) due to melt water input from the Alps whereas in winter river water $\delta^{18}O$ is dominated by input of Southern Germany precipitation reaching values of -8.5‰ (vs. SMOW).
$\delta^{18}O$ is related to discharge. Peak discharges are characterized by excursions towards lower values of river $\delta^{18}O$, whereas during low river stands high $\delta^{18}O$ values can be observed.

Freshwater mussels

Freshwater mussels of the genus *Unio* are large bivalves that are widely distributed in the Netherlands. They reach a size up to 10 cm long and an age of approximately 12 years. Shell material is precipitated in clearly visible seasonal growth bands. Characteristics of water chemistry are fixated in these growth bands, usually in equilibrium with the ambient water.

Freshwater mussels can serve as an archive for past water compositions.

Unio tumidus in life position.

$\delta^{18}O$

The $\delta^{18}O$ ratio of a shell is influenced by:
• Water $\delta^{18}O$: freshwater mussels fixate oxygen in their shell's carbonate with a $\delta^{18}O$ that is in equilibrium with the ambient water.
• Temperature: differential fractionation of oxygen isotopes at different temperatures results in a decrease of $\delta^{18}O$ with increasing water temperature

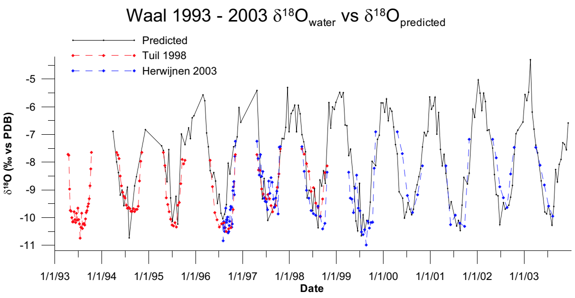
If temperature and water $\delta^{18}O$ are known, shell $\delta^{18}O$ can be predicted. Predicted values usually correspond well with measured shell $\delta^{18}O$.

Research questions

Do dark lines in transverse sections of the shell correspond with winter growth stops?

How well can $\delta^{18}O$ values of shells of *Unio tumidus* be predicted if temperature and water $\delta^{18}O$ are known?

The river Waal during high water levels.



Shell $\delta^{18}O$ of two shells from the Waal compared to predicted shell $\delta^{18}O$.

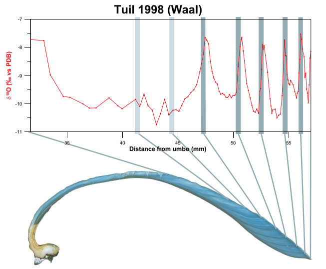
Results

All shells show a distinct seasonality in $\delta^{18}O$, values corresponding well with values predicted from water temperature and $\delta^{18}O$.

During winter the mussels do not grow. Winter $\delta^{18}O$ is therefore not recorded in the shell. Winter growth stops are characterized by a narrow peak in $\delta^{18}O$ values.

$\delta^{18}O$ peaks correspond well with dark growth bands in the shell, however some fainter dark bands do not show any relation with $\delta^{18}O$ values.

Shell $\delta^{18}O$ is a reliable proxy for reconstructing river $\delta^{18}O$.



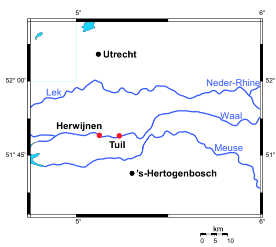
Correspondence between growth lines and shell $\delta^{18}O$ in a thin section of *Unio tumidus* from Tuil (1998).

Material & Methods

Two shells of *Unio tumidus* from the river Waal were analyzed. One was collected in August 1998 near Tuil. The other was collected in August 2003 near Herwijnen during extremely low water levels.

Shells were embedded in epoxy resin and thin sections were made transversely to the growth lines. These were photographed, and growth stops, characterized by narrow dark lines, were visually counted and the thickness of growth increments was measured. Subsequently the thin sections were sampled at a ca. 150μm resolution and analyzed for $\delta^{18}O$.

Predicted values of shell $\delta^{18}O$ were calculated using water temperature and $\delta^{18}O$ records from RIZA. Predicted $\delta^{18}O$ and shell $\delta^{18}O$ were compared.



Map of a part of the Dutch Rhine-Meuse delta showing the river Waal and locations of shell collections. For reference the cities Utrecht and 's-Hertogenbosch are indicated.

Future work

Having determined that $\delta^{18}O$ of freshwater mussels is a reliable proxy for past water conditions, this method can be applied to other recent and Late-Holocene specimens.

The first data of a monitoring experiment will soon be available. In this experiment living mussels are cultivated in the rivers Meuse and Lek. For the growing season of 2006 relations between shell $\delta^{18}O$ and water variables such as water $\delta^{18}O$, temperature, pH and trace element concentrations will be determined.
Other recent shells will be analyzed and shell $\delta^{18}O$ will be compared with recorded data such as river discharge and temperature. Shells from Rhine and Meuse from the same time periods will be compared.

Ca. 1000 year old *Unio tumidus* from the former river Daver at Kerk-Avezaath (Netherlands).

Shells will be analyzed from archaeological sites of the following time periods:
• Little Ice Age (ca. 1500-1700 A.D.)
• Medieval Climate Optimum (ca. 1000-1200 A.D.)
• Roman Period (ca. 0-300 A.D.)
• Bronze Age (ca. 4500-2500 B.P.)
Reconstructions of river discharge and frequencies of floods, droughts and melt water fluxes will be made.