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Studies on the chemistry of interstitial water taken from defined horizons in the fine sediments of bivalve habitats in several northern German lowland waters

I: Sampling techniques

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With 9 figures in the text

Abstract

In relation to a more detailed study on the ecological requirements of the pearl mussel *Margaritifera margaritifera* (L.) and other freshwater bivalves a device has been developed, which is technically uncomplicated and allow reliable water sampling from defined depths of the interstitium in lowland waters. In this paper the construction and use of this device will be described. A few representative vertical profiles of some limnological parameters are given to illustrate its use in a long term study.

Introduction

The freshwater macrobivales are by now on the red list of threatened species in this country (Bauer 1980, Bless 1980, Wiese 1984, Wächtler 1986, Bauer & Hochwald 1988). In many habitats populations are overaged and the lack of young mussels, which inevitably precedes the loss of the populations by a few years, has alarmed the investigators of several species (Dettmer 1982, Bednarczuk 1986, Maass 1987, Hüby 1988, Bauer & Hochwald 1988, Engel 1990). Most dramatic is the situation of *Margaritifera margaritifera* (L.) and *Unio crassus* (Philipsson).

As the young mussels of most species normally settle in the upper centimeters of the sediments (Hazay 1881, Israel 1913, Tudorancea & Gruia 1968, Bauer 1989), details on the changes of living conditions in these microhabitats are needed. That is why we have started a comparative programme to study sediments (Potamo-, Rhithro-, and Eulimnostygal; Husmann 1966) of various lowland waters which either still hold, or recently held, mussel populations.

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The probe system described by Husmann (1971a) for use in rocky substrates or coarse gravel was modified and adapted for our purpose, so that we could obtain reliable data from water samples for more than a year.

Locations

Three waters, in which the sediments were studied, were chosen according to the occurrence of freshwater bivalves (Dettmer 1982, Fleischauer-Rössing 1987, Engel & Wächtler 1989, Engel 1990).

a) A lowland stream with a population of *Unio crassus*

This stream is typical for the northern German lowlands, in the formerly glaciated region. It is 16 km long, 2.5—3 m wide, 0.20—0.80 m deep. It has a flow rate of 12—15 cm/sec and a discharge of 0.3 m^3/sec. It drains an agricultural area which is largely without any industrial settlements. It is bordered by wet meadows, with in some places alder woodland [*Alnus glutinosa* (Gaertn)] which mostly include large nettle beds [*Urtica dioica* (L.)]. The aquatic vegetation is predominantly *Elodea canadensis* (Michx) and *Glyceria* spec. According to the classification of Otto & Braukmann (Braukmann 1984) this water is of type cFl.

The substrate is typically 40 cm thick, consists of coarse sand, partly with clay constituants (Hartge 1971) and is regularely displaced. Frequent fish species are: dace [*Leuciscus leuciscus* (L.)], gudgeon [*Gobio gobio* (L.)], rudd [*Scardinius erythrophthalmus* (L.)] and three spined stickleback [*Gasterosteus aculeatus* (L.)].

b) A lowland stream with a *Margaritifera margaritifera* population

This is a typical stream of the northern German heathlands, of 23 km length, a maximum width of 5 m, 0.50—1.50 m depth, and is still largely uninfluenced by man's activities. It is characterized by high water quality, high flow rate, low temperature during both summer and winter, high oxygencontent, low calcium and low primary production. In the aquatic vegetation a *Callitricho-Myriophylletum alterniflori* (Dettmer 1982) prevails. In its course wet meadows and woods alternate. The banks are mostly covered by natural alder woodland.

The sediment varies within small distances from sand to gravel. The prevailing fish is the brown trout [*Salmo trutta* (L.)]. This running water corresponds to type sFl of Otto & Braukmann (Braukmann 1984).

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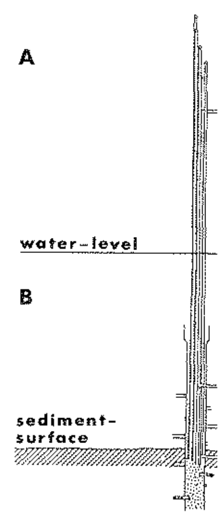


Fig. 1. The sampli

c) A lake in the lowlands with populations of *Unio pictorum* and *Unio tumidus*

This lake, situated in the ice marginal valley of the River Leine, is 18 ha in area and is 4—8 m deep. It is of a very recent origin being derived from a former gravel pit, worked during 1967—1975. The water level changes markedly during the year as the lake communicates with the River Leine via its ground waters. At high water levels, particularly in winter, there is surface communication with the river. Within the lake there are three islands with dense vegetation, mainly *Salix* spec. Except for these islands and the northwestern part, the banks have only a sporadic stock of trees. The sediment of the sampling sites mainly consists of fine sand. Pike [*Esox lucius* (L.)], pikeperch [*Lucioperca lucioperca* (L.)], perch [*Perca fluviatilis* (L.)], carp [*Cyprinus carpio* (L.)] and roach [*Rutilus rutilus* (L.)] are frequent fish.

In each of these waters three to five probes (see below) were installed, from which water samples were taken every two weeks for more than one year. Results from one location at water **a.** from January 1988 to February 1989 are given here as representative data to illustrate the technical approach.

Technique

The sampling device (Fig. 1) consists of a mobile unit (A) and one left permanently in place (B).

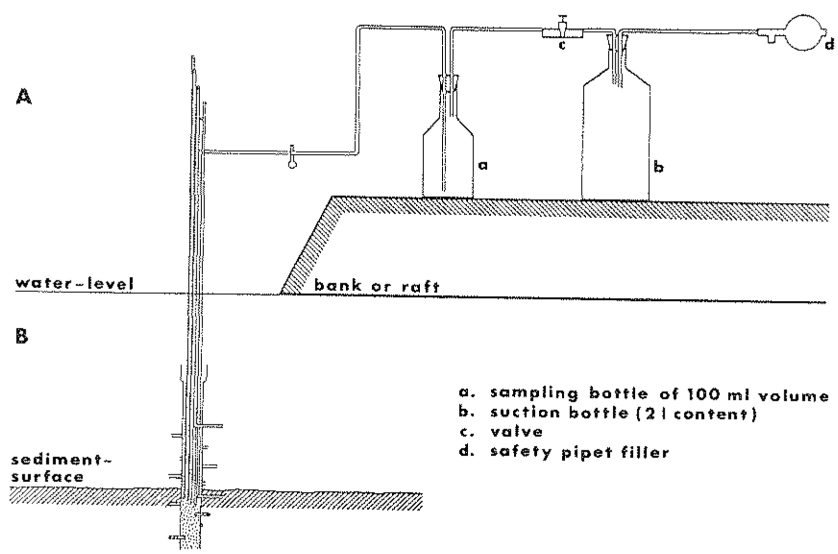


Fig. 1. The sampling device consists of a mobile unit (A) and a stationary one (B).

a) Mobile unit and sampling method

The mobile unit allows one to take defined (100 ml) samples of interstitial water. By means of a safety pipette filler or hand vacuum pump a partial vacuum is built up in a suction flask connected to one tube of a sampling bottle. The second tube from this bottle leads to the stationary unit to which it is fitted by suitable plastic couplings, so that samples from defined levels can be drawn, after the water standing in the tubes has been discarded.

O_2-content, conductivity and pH are determined immediately in the sampling bottle (Fig. 1, a). For the laboratory determination of NH_4^+, NO_3^- and PO_4^{3-}, samples were chloroformfixed in the field and then either processed immediately or stored frozen at −20 °C until use.

The stationary unit (Fig. 1, b) allows sampling from defined depths. The number of horizons to be studied and the sampling depth can be varied according to the investigation intended. In this study interstitial water was taken from 0, 1, 2, 3, 4, 5, 7, 9, 15, 20, 30, and 35 cm sediment depth. In running waters some additional levels above 0 have to be provided in order to adapt the

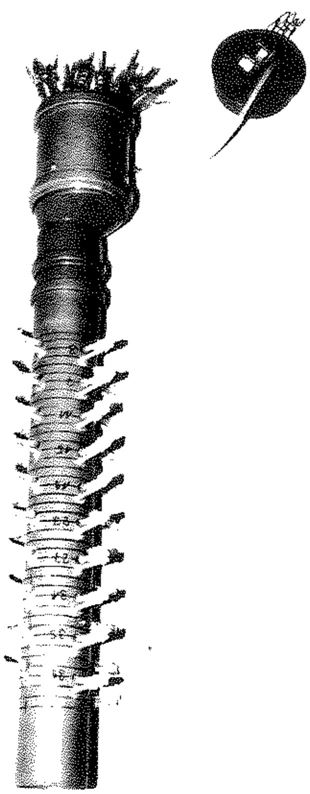
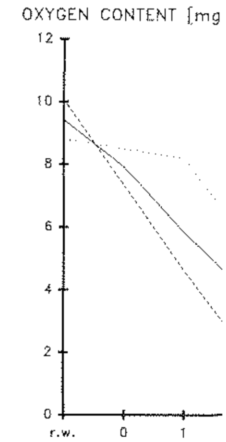


Fig. 2. Construction of the stationary unit.



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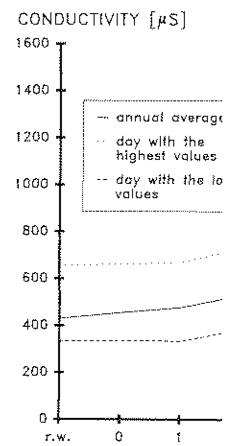

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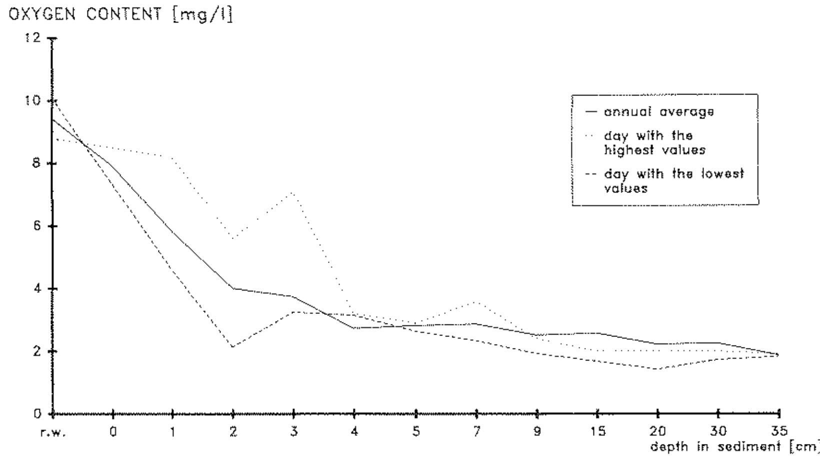


Fig. 3. O_2-content in the sediment of an *Unio crassus* habitat.

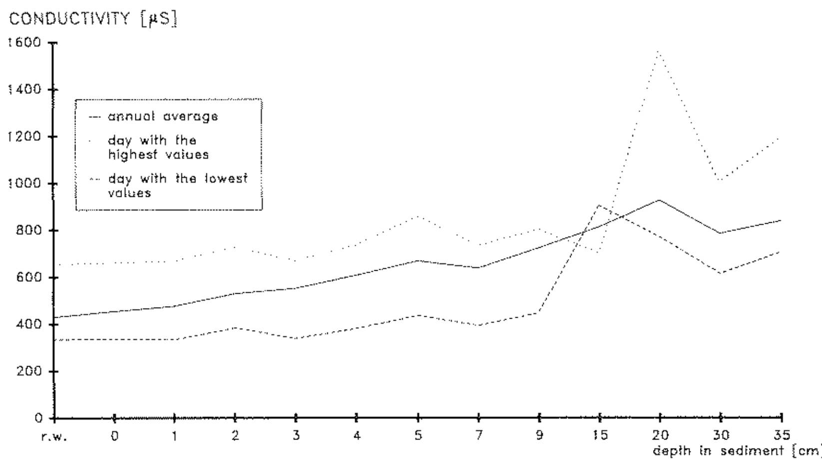


Fig. 4. Conductivity in the sediment of an *Unio crassus* habitat.

sampling levels to possible variation of the sediment surface by drifting sand or organic debris.

b) Construction of the stationary unit (Fig. 2)

The sampling tubes for each level are housed in a commercially available 70 mm diameter PVC pipe, on the upper part of which a 100 mm neck piece closed by a lid is fitted. At each sampling level a silicon tube of 4 mm diameter, 1.5 mm wall thickness, projects from the pipe. These projecting tubes are

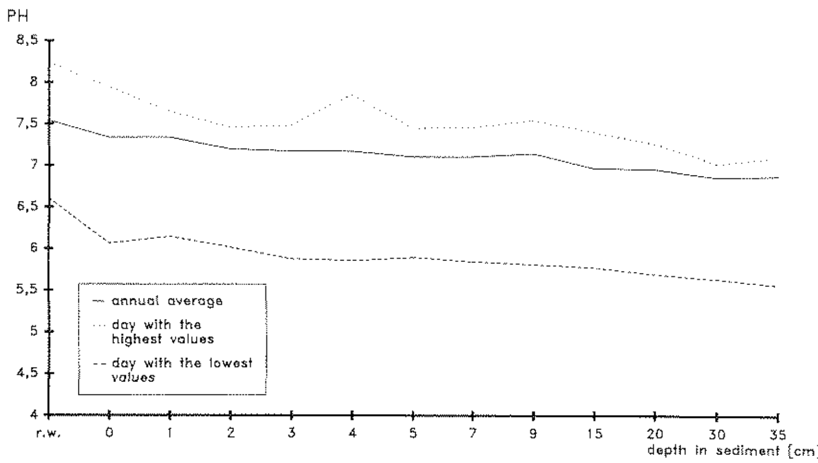


Fig. 5. pH in the sediment of an *Unio crassus* habitat.

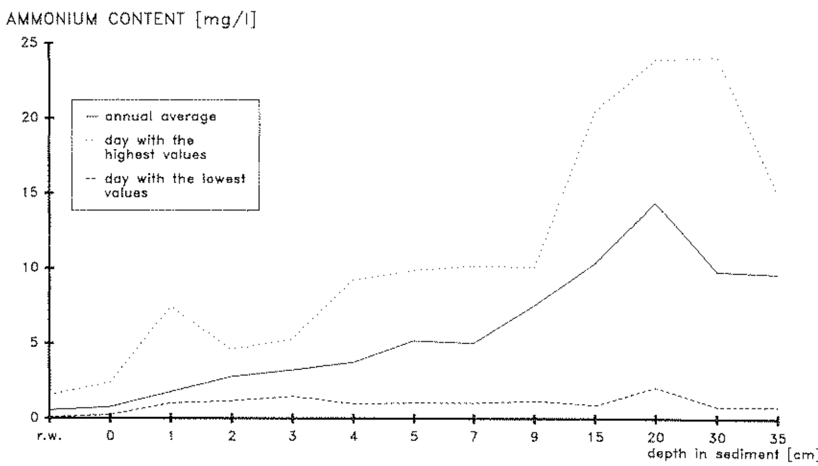
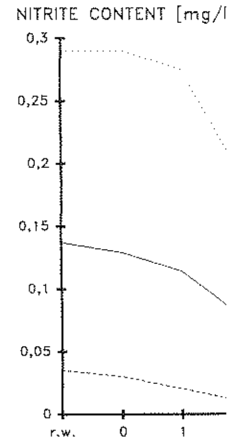


Fig. 6. Ammonia-content in the sediment of an *Unio crassus* habitat.

mechanically protected by a plastic wall plug extending 5 cm from the pipe at a right angle. The exits for the tubes of adjacent levels are displaced by 90°. The openings of the silicon tubes are covered with 200 μm plankton net. The upper ends of the tubes (their length is adapted to the water depth) are housed in the PVC pipe until connected to the sampling bottles and are marked with coloured rings ("shrinkage tubes for electronic wiring") so that each level can be identified reliably even after one year and more in the water. The PVC pipe is dug vertically in the sediment and sampling can start only after a period of at least two weeks to allow restabilisation of the sediment around the pipes.



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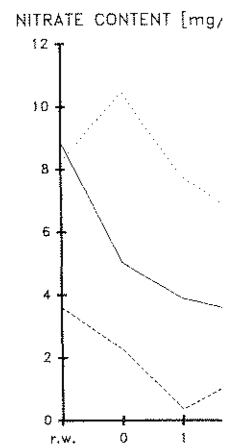

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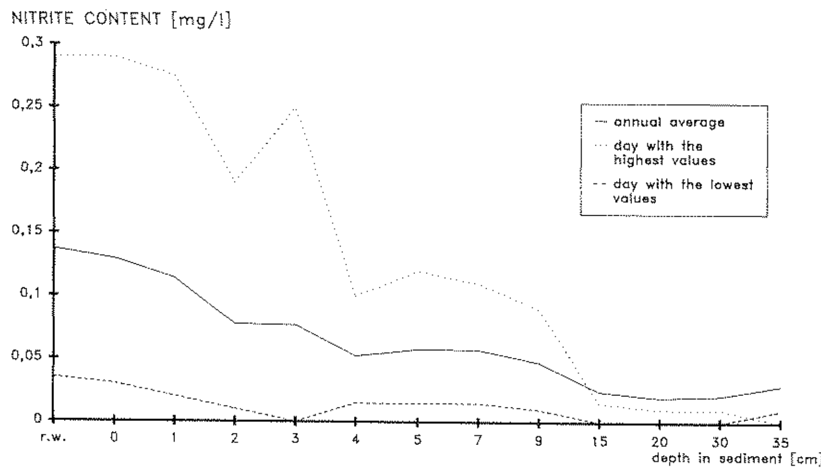

Fig. 7. Nitrite-content in the sediment of an *Unio crassus* habitat.

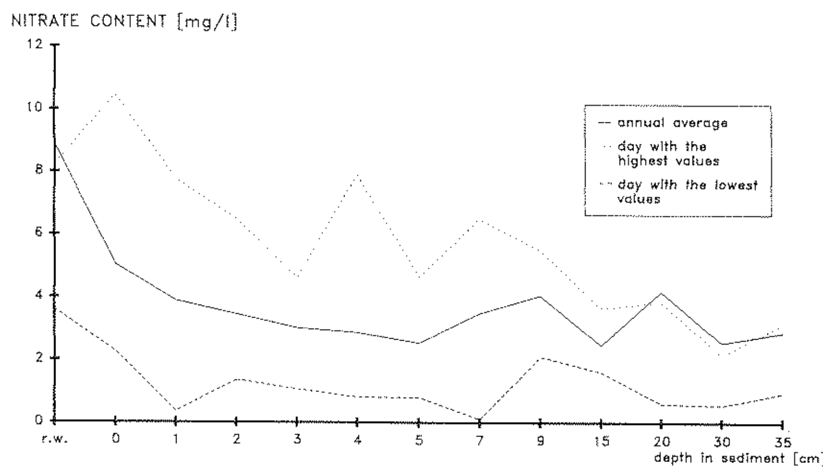

Fig. 8. Nitrate-content in the sediment of an *Unio crassus* habitat.

Observations

In the Figs. 3—9 some results from the *Unio crassus* habitat are shown. The annual average of several parameters found in defined sediment depths is given (——), together with the profiles from the days with the highest (· · · · ·) and the lowest (- - - - -) observed values. The graphs indicate a consistent layering at varying levels. Horizon specific seasonal changes in the concentration of several parameters can be recognized.

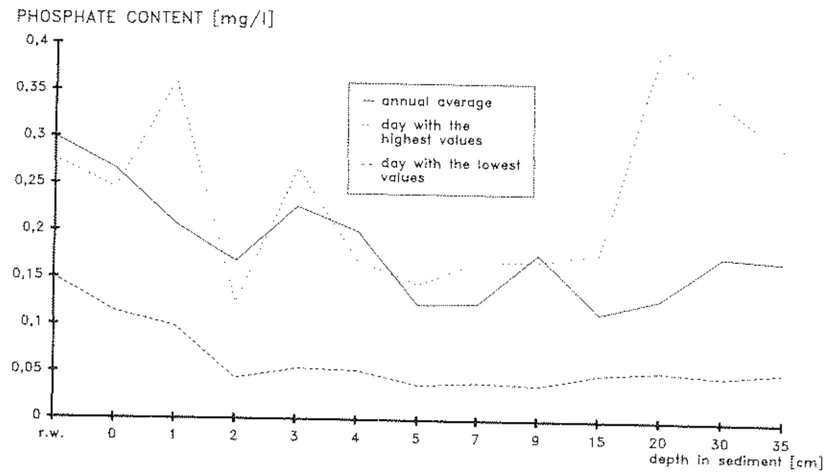

Fig. 9. Phosphate-content in the sediment of an *Unio crassus* habitat.

Discussion

The concentration of substances within the interstitium largely depends on the type of waterbody and the specific sediment structure. In all locations characteristic depth profiles for the parameters studied were found. From the observation that the values obtained for each level are so distinct from each other, it is concluded that the potential problem of contamination between mixing within adjoining horizons, caused by the intrusion of the sampling device is not sufficiently great to conceal the profiles.

In running waters with changing sediment surfaces adjustment of the zero level is necessary on each sampling occasions in order to keep the profile comparable over a longer period. Even in situations where the zero level fluctuates between +30 cm and −30 cm over the year, consistent layering was found for the chemical parameters.

The observations on varying concentrations of several substances in the upper sediment layers are in good agreement with previous data from lake sediments (Schwoerbel 1961, Iwamoto et al. 1978, Andersson 1985) and from gravel beds in running waters (Husmann 1971 a and b, Iwamoto et al. 1978).

To some extent the suitability of a given site for mussels can be predicted from the chemical profile of its substrate.

Over a period of more than one year the stationary unit has proved fairly resistant to mechanical damage. It proved to be well suited for continuous sampling through the seasons although there are of course restrictions during really cold winters. Low cost and ease of construction, as well as mechanical stability, make this sampling unit a useful tool for longterm studies of the living conditions for aquatic organisms in the upper sediments of lowland waters.

Summary

In the course of sediment studies of freshwater bivalve habitats, a sampling technique for interstitial water, as originally described for rocky beds of running waters by HUSMANN 1971, was modified for longterm use in sandy and gravelly sediments of both running and standing lowland waters. Its construction, its use and some representative results obtained by its application are described.

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