Oligochaete communities as biological descriptors of pollution in the fine sediments of rivers

Michel Lafont
Laboratoire d'Hydrobiologie du CEMAGREF; 3, Quai Chauveau, F-69009 Lyon, France

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Abstract

This study emphasizes the usefulness of Oligochaeta communities as descriptors of pollution in the fine sediments of large rivers. Two indices of biological quality of fine bottoms are proposed and are related to chemical parameters of the water. Tentative proposals are made for an empirical classification of polluted fine sediments.

Introduction

There are several difficulties in using Oligochaeta to assess the impact of human activities on large rivers. Each habitat category (fine sediment or stones and gravel, etc.) plays an important role in population dynamics of worms. Therefore, when evaluating the pollution tolerance of worms and describing biological pollution indicators, it is necessary to refer to the kind of bottom sediment (Lafont, 1977; Marshall & Winterbourn, 1979). The other problem is that it is almost impossible to find an unpolluted situation in large rivers. On the other hand, we can try to generalize the results obtained from a given sediment to the same sediment in other rivers considering the high degree of similarity between French oligochaete communities (Lafont, 1982).

Methods and sampling areas

The sampling and sorting protocols are to be found in two papers (Juget & Lafont, 1982; Wasson & Lafont, 1982). Samples were taken from permanent fine sediments (particles of $\leqslant 50$ μm diameter ranging from 30 to 80% in weight), at least 15 cm thick. Forty sampling sites situated in rivers of the East of France were studied (Lafont, 1982).

Results

The most damaged areas of the 40 sampling sites from a chemical and biological point of view, for example the river Saône at Pagny (Table 1), are those where fine sediments contain the lowest number of Oligochaeta species and the highest relative abundance of Tubificidae without hair setae (mature and immature worms). It is somewhat surprising to find that in large rivers such as the Rhône or Saône, Tubificidae with hair setae predominate in less polluted areas (Lafont, 1982; Lafont & Juget, 1976).

Proposals for two indices of biological quality of fine sediments

Two indices of biological quality of fine sediments are proposed:

$I_o = 10\ S \cdot T^{-1}$, where S is the total number of species found in the sediment, T is the relative abundance of Tubificidae without hair setae (ma-

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Table 1. Saône river, seasonal values of I_0 and E_0 compared to minima (min.) and maxima (max.) of several chemical parameters of the water (from Wasson, 1980).

Sampling sites	Months	Number of species	Tubificidae %	Tubific. without h. setae	I_0	E_0	BOD_5 mg l^{-1} min.	max.	NH_4^+ mg l^{-1} min.	max.	PO_4^{3-} mg l^{-1} min.	max.	Cl^- mg l^{-1} min.	max.
Tillenay	May	21	73.3	27.2	7.7	E_{11}								
(slightly	Aug.	10	57	38	2.6	D_5	1.2	3.6	0.07	0.23	0.14	0.85	9	17
polluted)	Sept.	11	79	49	2.2	C_6								
Marnay	May	10	43.2	38.8	2.6	D_5								
(below the	Aug.	7	86	50	1.4	C_4	1.7	3.7	0.11	0.81	0.11	0.74	25	225
town of	Sept.	8	97.6	72	1.1	B_4								
Chalon)														
Pagny	May	7	97.2	89.2	0.8	B_4								
(below	Aug.	9	92.7	79.3	1.1	B_5	2.	3.8	0.10	0.66	0.21	0.98	44	450
chemical	Sept.	11	87.8	75.6	1.5	B_6								
outflow)														

ture + immature worms) taken from the whole Oligochaeta community of the sediment.

The second index E_0 is a composite one. Each letter represents the code for relative abundance of Tubificidae without hair setae. These classes are based upon observations made on the 40 sampling sites (Lafont, 1982): A = ≥91%, B = 71 to 90%, C = 46 to 70%, D = 36 to 46%, E = 16 to 35%, F = ≤15%. F can represent either polluted or unpolluted small streams and perhaps other situations we have not yet seen. Then Tubificidae with hair setae and *Tubifex tubifex* show mass development. This phenomenon is well known in the literature. Each number is the code for species richness: 1 = 1–2 species, 2 = 3–4 species, 3 = 5–6 species, etc. In our samples, the minimum I_0 value is 0.1 and is corresponding to $E_0 = A_1$ (Tubificidae without hair setae = 100%, one species found). The maximum I_0 value is 7.7 and is corresponding to $E_0 = E_{11}$.

Discussion and conclusion

In the river Saône (Table 1), physico-chemical measurements were made in the water column over a minimum period of at least 12 months and provide good representative data of the chemical condition of the water. As seen in Table 1, the lowest values of I_0 (0.8 to 2.6) and E_0 (B_4 to D_5) are related to high contents of NH_4^+, PO_4^{3-} and Cl^- in the water. Oligochaeta can be affected by toxic effects of various substances in the sediment, and chemical effluents are well integrated by sedentary burrowing Oligochaeta. Moreover, all sediments are not contaminated in the same way and have various toxic effects on Oligochaeta (Chapman *et al.*, 1982). In our polluted fine sediments the most abundant species are: *Potamothrix hammoniensis, Limnodrilus claparedeianus, L. hoffmeisteri, L. udekemianus, Tubifex tubifex, T. ignotus, Amphichaeta leydigii, Vejdovskyella intermedia, Dero digitata, Specaria josinae, Marionina riparia.* The first six species are well known to be resistant to all kinds of pollutions in rivers (Brinkhurst, 1966, 1980; Aston, 1973; Howmiller & Scott, 1977; Ladle, 1971; Marshall & Winterbourn, 1979).

In contrast, the other five species are not known to be pollution tolerant in large rivers. It is necessary to consider that the number of resistant Oligochaeta is probably much greater than generally believed. All these observations emphasize results obtained by Chapman *et al.* (1982).

Tentative proposals are made in Table 2 for an empirical classification of polluted fine sediments. With indices I_0 and E_0, we try to define pollution impact (I_0) and a biological parameter (E_0) of sediment. In my opinion, definition by means of the Oligochaeta communities of biological parameters of the muds (Lafont & Juget, 1981) is a way of assessing the pollution impact and can give an approach to a typology of the fine sediments of rivers.

Table 2. Biological classification of fine sediments of large rivers according to the degree of pollution (from Lafont, 1982).

E_o	I_o	Comments - Diagnosis
E_{11} E_{12}	5.1-8	slightly polluted sediments
D_{14}		*21-28 species* - Tub. without hair setae = *15-45%*
E_7 D_8	3.1-5	medium level of pollution - Sediments begin to become toxic but species richness can be still high.
C_{11} B_{12}		*14-24 species* - Tub. without hair setae = *15-90%*
E_5 D_6 D_9	2 -3	high level of pollution - Toxicity increases; species richness decreases.
C_7 C_6		*10-20 species* - Tub. without hair setae = *15-90%*
B_{10} B_9 B_8		
C_6 C_5	1.5-1.9	- idem - very high level of pollution.
B_7 B_6		*10-14 species* - Tub. without hair setae = *46-90%*
C_4 B_5 B_4	1 -1.4	reduced biocenosis - sediments are very toxic
A_5		*8-10 species* - Tub. without hair setae = *46-100%*
B_4 B_3	0.1-0.9	ultimate stage of pollution before azoic sediments
A_4 A_3 A_1		*1-8 species* - Tub. without hair setae = *71-100%*

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