BIOMASS AND BIODEGRADATION OF MOLLUSK SHELL CHITIN IN SOME MARINE SEDIMENTS

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ABSTRACT

Chitin was mesured in some marine sediments gathered in Calvi bay (Corsica, Mediterranean Sea) and in North Sea (Belgium coast), at depths from 0 to 1150 meters.
Chitin was present in every type of sediment. Chitin biomass values were low in most mediterranean sediments (less than 0.2 $mg.g^{-1}$ decalcified material) but amounted 2.8 $mg.g^{-1}$ decalcified material in a "Gryphus gravel" (Calvi bay, at depth around 200 meters) and 1.8 $mg.g^{-1}$ decalcified material in intertidal organoclastic sands of North Sea.

In most cases, chitin in sediment originated mainly from mollusk shells, which seem to withstand biodegradation to some extent, better than other chitinous structures.

An experimental study of mollusk shell biodegradation in situ showed an important decrease of chitin content during the first six or twelve months after immersion, due to chitinolytic molds, blue-green algae and meiofauna. It thus appears that chitin of dead mollusk shells does not accumulate on a large scale in most marine sediments, with some remarkable exceptions.

INTRODUCTION

The well-known unusual resistance of the polysaccharide chitin to chemical degradation may suggest an important accumulation of chitin in natural environment, after the death of organisms with chitinous exoskeleton. As a matter of fact, there is a need for quantitative data on chitin accumulation in sediments, as well as on the biodegradation rate of this polysaccharide under natural conditions.

In order to elucidate these aspects of chitin ecology and to appraise the possible interest of some marine sediments as alternative sources of chitin for industrial exploitation, some ecological and biochemical investigations were performed in the North Sea near belgian coast and in the Mediterranean Sea near Calvi bay (Corsica, France). The biomass and fate of chitin from mollusk shells was more especially studied.

EXPERIMENTAL

Sediments were gathered by scuba-diving or using a "Shipek" grab, washed (distilled water) and dried. Some of them were sorted in order to estimate the relative importance of organoclastic fragments and to identify their origin.

Samples of sediments were weighted, decalcified in 0.5 N HCl and treated by hot alkali (NaOH 1 N, 100°C, during 6 hours) in order to remove proteins and allow chitin accessibility to chitinase hydrolysis. Chitin amounts in residual material were mesured by enzymatic method (1,2) using highly purified chitinases (Koch-Light, 1 mg/ml). Enzymatic hydrolysis was performed during 10 hours at 37°C and pH 5.2. After addition of N-acetyl-D-glucosaminidase (from lobster serum), N-acetylglucosamine was estimated by colorimetric method (3).

Biodegradation studies were performed on fragments of mollusk shells or on isolated shell layers from different species belonging to Bivalves, Gastropods and Cephalopods. The shell fragments, contained in 0.18 mm - mesh nylon bags were immerged and settled on a shelly gravel in Calvi bay (Corsica Mediterranean Sea), at a depth of 37 meters. They were taken off every three months during 2 years and used for endolithic organisms detection and identification and for biochemical analyses.

RESULTS.

A.- Chitin biomass in sediments.

As shown in table I, the amounts of chitin were generally low, below 0.2 $mg.g^{-1}$ decalcified sample. Some sediments contained higher amounts : shelly gravels in the mediolittoral (intertidal) zone of the North Sea (chitin content from 1.4 to 1.8 $mg.g^{-1}$ decalcified sample) and a deep eulittoral gravel (-175 m), a thanatocoenosis interpreted as a transition between circalittoral and bathyal regions (2.8 $mg.g^{-1}$ decalcified sample). This last sediment is frequent at the fringe of continental plateau, west of Corsica (Mediterranean Sea).

The amount of chitin of a sample did not appear to be related to the depth of the sampling (from 0 to 1150 m.).

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Table 1. Chitin content in some sediments of North and Mediterranean Sea

Sediment		Depth (m)	Average calcification degree (1)	Average mollusk shells (1)	Total chitin in sediment $g.g^{-1}$ (2)	Chitin of organoclastic fraction, % total chitin (3)	Chitin of mollusk shells, % total chitin (3)
Shelly gravel	A	0	49.4	44	1435.4	70	70
	B	0	99.5	98	1788.5	100	100
Posidonia bed gravel		37	19.2	10	40.3	59	52
Terrigenous sands		40	22.4	6	16.4	62	52
Circalittoral sands	A	47	26.3	6	193.6	-	19
	B	145	31.8	9	45.5	-	28
Gryphus beds		175	90.4	17	2808.8	49	3
Bathyal muds	A	440	60.4	1	81.2	18	16
	B	1150	56.3	2	63.1	19	13

(1) Percent total dry weight

(2) $g.g^{-1}$ decalcified sediment

(3) Percent total chitin

The "organoclastic" fraction of sediments (detritic pieces of skeletal structures) is highly variable , from 3 to 99 % of the weight of the sample. Chitin is always found in this fraction, but in most cases a great part of the sedimentary chitin can be found in the remaining fraction of sediment, after sorting organoclastic fragments. This means that a part of chitinous skeletal structures is weathered enough to be integrated to this fraction as unrecognizable material. This seems particularly true in deep water samples (bathyal muds) where more than 80 % of the sedimentary chitin is found in the fine, non organoclastic, fraction.

The organoclastic fraction was composed of a wide variety of skeletal remains of organisms; mollusk shells were always present, even if not particularly abundant. The chitin of their shell organic matrix contributed greatly to the chitin biomass of the sediments.

B.- Biodegradation of mollusk shell chitin in marine environment.

The process of chitin degradation in pieces of shells settled on a shelly gravel in Corsica (37 meters deep) was followed during 2 years (fig. 1).

In the case of mussel (Mytilus edulis) mother of pearl, the degradation of chitin as well as that of the total organic matter was particularly fast during the first six months of experiment. After one year of immersion, chitin amounted less than 10 % of its original weight. It seemed that degradation process was considerably reduced during the second year of experiment.

In Pinna prisms, the phenomenon was somewhat similar, but chitin degradation carried on during the second year of immersion. After two years, more than 40 % of chitin was not yet hydrolysed.

In Tridacna crossed lamellar structure, the organic matrix weathering is delayed. It is particularly fast during the second half of the first year of experiment, but degradation was not detected during the second year of immersion.

The chitin degradation is essentially due to the bacteria and meiofauna of the upper sedimentary layers and to microborers in the shells (blue-green algae and endolithic molds are particularly abundant). We verified that molds and bacteria were able to secrete chitinases and proteinases: moreover a strong chitinolytic activity was detected within weathering mother of pearl (after six months of experiment).

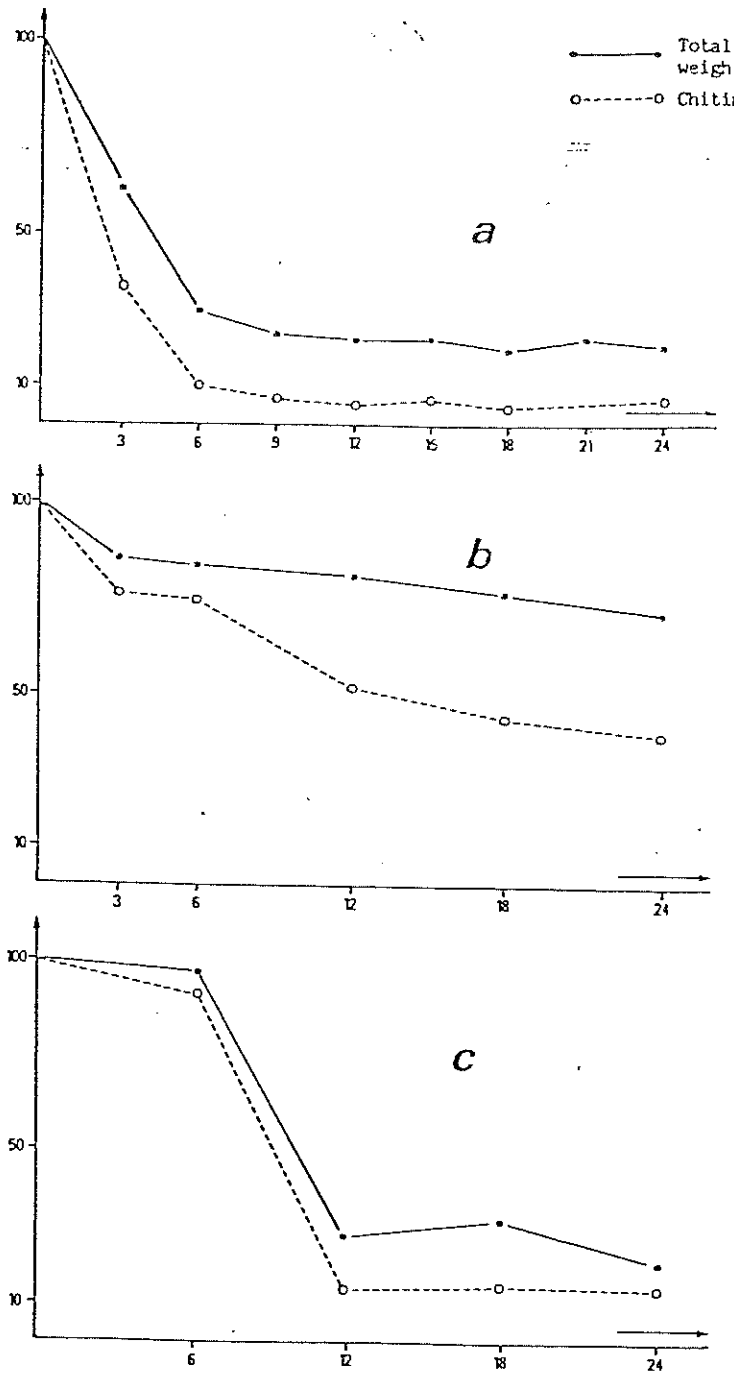

Fig. 1. Total organic matter and chitin biodegradation in mollusk shells settled for two years on a shelly gravel (37 m deep, Mediterranean Sea).
a : isolated mother of pearl of Mytilus edulis
b : isolated prismatic layer of Pinna nobilis
c : isolated crossed-lamellar layer of Tridacna gigas.

DISCUSSION

The mode of constitution of the chitin biomass of sediments is totally different than that of other biocenosis on hard substrates (4,5). The chitin content of sediments depends not only of the initial chitin content of skeletal components but rather of the way those skeletal structures withstand weathering.

Mollusk shells seem to be more resistant than most other skeletons. Nevertheless, chitin biodegradation in mollusk shells is fast, resulting from the combined action of endolithic organisms (blue-green algae, molds,...), meiofauna and chitinolytic bacteria (6.7).

The kinetics of chitin biodegradation in marine sediments, and the low values of chitin biomass found in most cases, lead us to the conclusion that the chitin does not accumulate in organoclastic sediments on a large scale. Most of the chitin is rapidly hydrolysed and reintegrated in carbon and nitrogen cycles of marine ecosystem.

It is doubtful that marine sediments could become valuable alternative sources of chitin.

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