

The Protection of Particulate Organic Matter Within Aggregates in the Water Column



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Abstract

The occlusion of organic matter within aggregates of mineral particles has been proposed as one mechanism for organic matter preservation in terrestrial soils and marine sediments. This mechanism of protection may also be important in the water column, where it may contribute to the export of organic matter from the surface mixed layer. To determine if the compartmentalization of organic matter within aggregates has any effect on decomposition, we approached this question in reverse, by testing the effect of disaggregation on decomposition. Sinking particles >125 μm were collected from Long Island Sound using a weighted plankton net. Half the particles were sonicated to disrupt aggregates, and half were not. Decomposition of particles in the two treatments was monitored through analysis of particulate organic carbon (POC), nitrogen (PN), and total hydrolyzable amino acids (THAA). There was no consistent difference between treatments in the rate or final extent of decomposition of these parameters. It is possible that within the range of aggregate porosities (or interparticle void spaces) common in the water column, organic matter is not protected from decomposition. To determine this, we must first account for the possibility that aggregates quickly re-formed after sonication in this experiment.

Methods

Long Island Sound particles were collected in Oct. 2004 from a depth of 2 m using a weighted 125- μm mesh plankton net hung in a vertical position. Samples were homogenized and diluted with seawater. Half the particles were sonicated at 47 kHz for 30 min. to disrupt aggregates (exposing the internal organic matter to decomposition) and half were not.

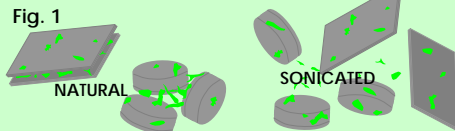


Fig. 1: Theoretical effect of sonication.

Particles were incubated in the dark at 20°C for 1.5 months and sub-samples were removed and filtered in duplicate every 7d onto combusted 0.7- μm GF/F filters. Particulate organic carbon and nitrogen were determined by elemental analysis. Total hydrolyzable amino acids (THAA) were determined by high-performance liquid chromatography after hydrolysis in 6N hydrochloric acid. Principal components analysis was performed on the amino acid data (after standardizing the mol% of each amino acid by subtracting its mean and dividing by its standard deviation) to investigate compositional differences. An additional sample was later collected from Long Island Sound (in Feb. 2006) and examined by light microscopy before and after sonication.

Results

Images collected by light microscopy indicate that sonication is capable of breaking aggregates up into smaller particles (Fig. 2). Despite this, there was no consistent difference between treatments in the rate or final extent of POC, PN, or THAA decomposition, the fraction of POC present in THAA, or amino acid composition (Figs. 3,4).

Decomposition of both treatments was best described by a first-order exponential decay model involving two pools with different reactivities: $C(t) = C_1(0)e^{-k_1 t} + C_2(0)e^{-k_2 t}$. After 1.5 months, approximately 11-12% of initial POC, 8% of initial PN, and 7-10% of initial THAA remained in both treatments (Fig. 3a-c). THAA accounted for about 70% of PN throughout the experiment (not shown). About 50-65% of POC was initially present as THAA; this decreased slightly to about 35-50% after 1.5 months (Fig. 3d). Principal components analysis of the amino acid composition data indicated that most degradation occurred before the 7d sample was taken (Fig. 4).

Fig. 2

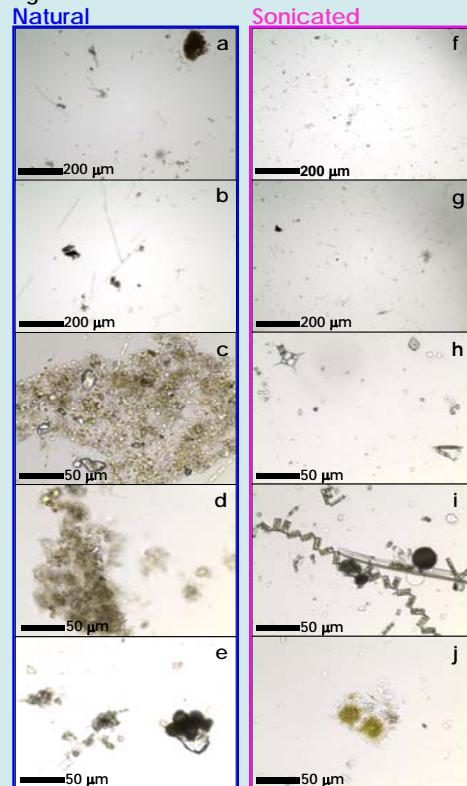


Fig. 2: Representative microscope images (100x, 400x) of natural (a-e) and sonicated (f-j) Long Island Sound samples (collected in Feb. 2006, not those used in experiment).

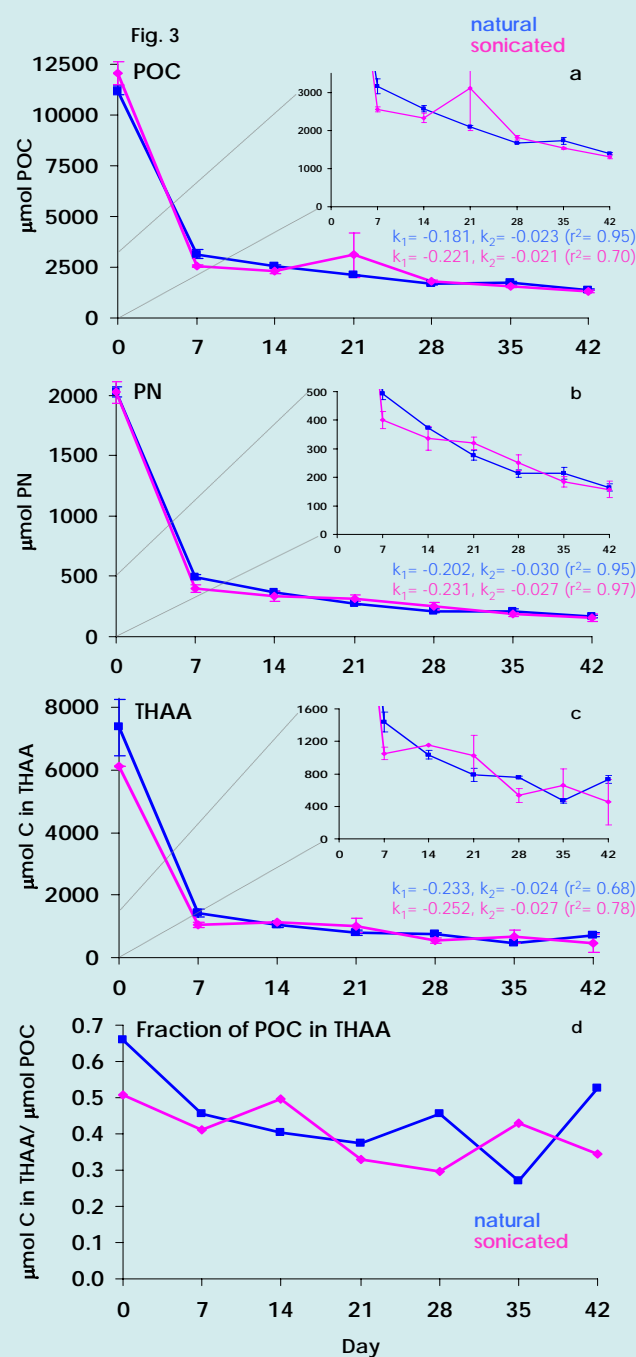
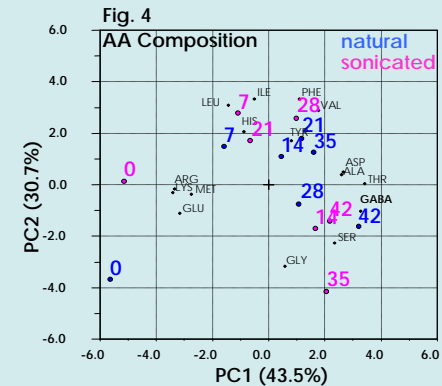


Fig. 3 (left): Decomposition of natural and sonicated Long Island Sound particles as determined from particulate organic carbon (a), particulate nitrogen (b), total hydrolyzable amino acids (c), and the ratio of total hydrolyzable amino acids to particulate organic carbon (d). Insets in right corners of a-c show expansion of lower y-axis for easier comparison of later time points. Rate constants k_1 and k_2 are, respectively, for the decomposition of an initial, more labile pool from 0-7d and a second, more refractory pool from 7-42d (r^2 in parentheses is for k_2).

Fig. 4 (below): Principal components analysis of amino acid composition data. Numbers represent days on which samples were taken. Axes are principal components 1 and 2, which explained most variance in the data (43.5% and 30.7%, respectively) and are scaled to the sample site scores. Variable loadings are scaled up 10x to fit axes. Samples cluster near the variables in which they were enriched. Samples with positive scores on PC1 were more degraded, as indicated by the highly positive loading of the decomposition indicator γ -aminobutyric acid (GABA).



Conclusions

Although it appears possible to disrupt aggregates by sonication, this did not affect decomposition of the Long Island Sound particles. Possible explanations for this finding include:

1. Within the range of aggregate porosities common in the water column, organic matter is not protected from decomposition.
2. Aggregates were initially broken up by sonication but re-formed quickly.

Possible directions for future work include:

1. Repeat experiment using microscopy to investigate possibility of re-aggregation.
2. Compare decomposition of unaltered particles with those that have been aggregated using rotating tanks.
3. Create aggregates of different porosities using various sizes of glass beads to determine effect of porosity on decomposition.
4. Any suggestions?

Acknowledgements: This work was supported by the NSF Chemical Oceanography Program and a Graduate Council Fellowship (Stony Brook University).