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THE MARINE SULFUR-CYCLE: IMPORTANCE OF *PHAEOCYSTIS* SP. IN DMS-PRODUCTION DURING A NEARSHORE SPRINGBLOOM

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Abstract

Potential enzymatic conversion of dimethylsulfoniopropionate (DMSP) to dimethylsulfide (DMS) was measured in natural seawater samples during the 1993 spring bloom off the Dutch coast. Good correlations were found with *Phaeocystis* sp. numbers, indicating the presence of a specific DMSP-lyase in this often so dominant algal species. The results suggest an important role of *Phaeocystis* sp. in the conversion of DMSP to DMS.

INTRODUCTION

Dimethylsulfide (DMS) is thought to be involved in the biological regulation of the climate: 90 to 95% of the aerosols found above remote oceans consist of non-seasalt sulfate that is formed by gas-to-particle conversion of the oxidation products of organosulfur gases (principally DMS). Aerosols serve as cloud condensation nuclei (CCN). The amount of DMS released into the atmosphere influences the number of CCN and thereby cloud droplet size, cloud albedo and, consequently, climate (Andreae 1990, Charlson et al. 1987, Charlson & Wigley 1994, Malin et al. 1992).
The flux of DMS from the ocean into the atmosphere is determined by its concentration in the water, which is the result of several production and removal processes (fig.1). In seawater DMS is produced from dimethylsulfoniopropionate (DMSP), a compound that is found in many marine microalgae (Keller et al. 1989). Conversion of DMSP into DMS and acrylic acid is thought to occur mainly after its release from the cells. Then, part of the DMSP is cleaved through enzymatic activity. Until now, attempts to quantify the processes as discribed in fig.1 have been scarce, but with today's state of knowledge, it is tempting to believe that only a small part of the DMSP-sulfur will ever reach the atmosphere (Bates et al. 1994). On the other hand, the processes described in fig.1, of course, never occur all at the same time and with the same strength. Therefore, it is important to investigate at what time which process is important, and what species are involved. In the literature it is mainly suggested that DMSP-lyase activity stems from bacteria. On the other hand, it was recently shown that an important DMSP containing species, *Phaeocystis* sp., also possesses a DMSP-lyase (Stefels & Van Boekel 1993).
The objective of this study was to investigate whether or not there exists a relation between the potential DMSP-lyase activity in natural waters and the occurrence of *Phaeocystis* sp. or any other algal species present.

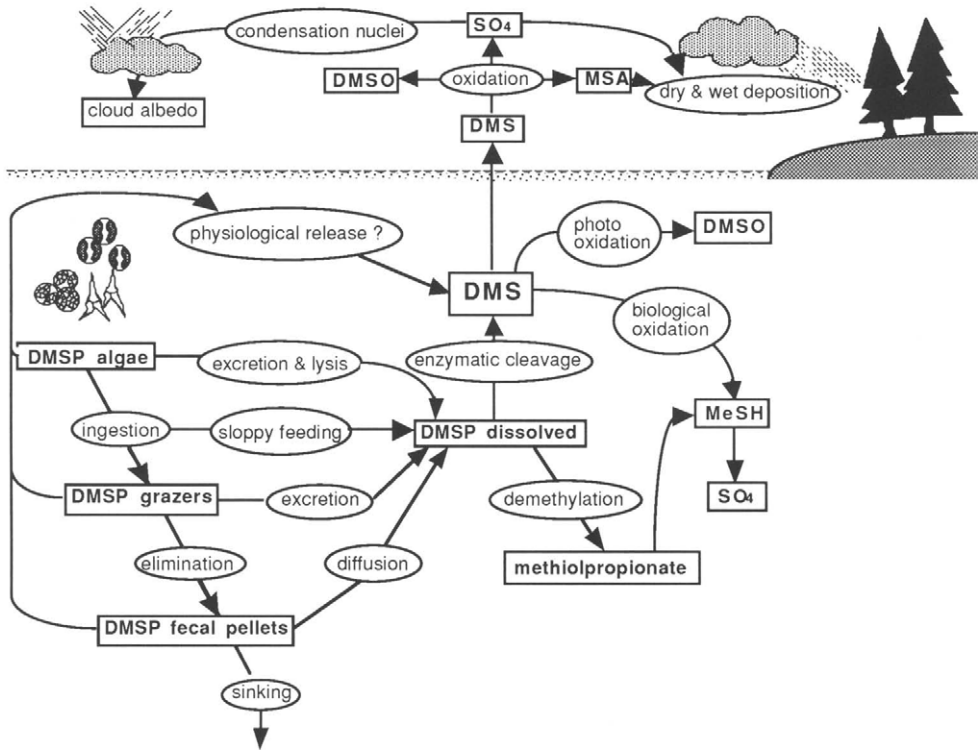

FIG. 1: Main production and consumption processes of DMS in the marine environment.

MATERIAL AND METHODS

With axenic *Phaeocystis* sp. cultures an enzyme essay was developed, and applied on natural seawater samples off the Dutch coast, taken during the spring bloom of 1993 with RV "Pelagia". To this end, surface water samples were taken. The particulate matter of 350-1000 ml was subsequently fractionated (in >100 µm and 10-100 µm fractions) and concentrated. Of each fraction subsamples were taken for cell counts; the remainder was immediately frozen at -80 °C. In the lab the samples were thawed; particulate matter was harvested through centrifugation and destroyed using a French Pressure Cell. To the crude extract a buffer with DMSP was added after which DMS evolution was measured in the headspace using a gas chromatograph equipped with a sulfur-specific Hall Electrolytic Conductivity Detector. Part of the crude extract was used for protein measurements.

RESULTS

During the cruise, the northern and offshore waters were dominated by the colony forming alga *Phaeocystis* sp., whereas the southern and central coastal waters mainly consisted of diatom species, giving a good impression of a typical spring phytoplankton bloom off the Dutch coast. DMSP-lyase activity measured in the samples proved to be mainly restricted to the >100 µm fractions in which the *Phaeocystis* sp. colonies were trapped. DMSP-lyase activity showed a

very good correlation with *Phaeocystis* sp. numbers (r^2=0.9660, n=23), but no correlation with any other abundant species, nor with total diatom numbers, total diatom biovolume or total protein.

DISCUSSION

In the literature, the conversion of DMSP to DMS has mostly been attributed to bacterial activity. Our results show, however, that the alga *Phaeocystis* sp. has a very active DMSP-lyase, specific for this species, which is potentially responsible for the conversion of DMSP to DMS during the early spring bloom off the Dutch coast. DMS production rates by *Phaeocystis* can be calculated for these waters, using the production rates measured in axenic cultures, *Phaeocystis* numbers and dissolved DMSP concentrations found during the cruise, and a mean depth of the mixing layer of 5 m. In the northern part of the study area, values ranged from 47 to 131 µmol m^{-2} day^{-1}. We have compared these production rates with the main abiotic loss factors. Loss by air-sea exchange was estimated to be 16.6 µmol m^{-2} day^{-1}; photochemical oxidation of DMS to DMSO is comparable with the flux to the atmosphere. Total abiotic loss rates can therefore be estimated to be approximately 30 µmol m^{-2} day^{-1}. This is in the same range as DMS production by *Phaeocystis*; indeed a 1.5 to 4.5 times overproduction of DMS can be calculated, potentially available for bacterial consumption. Considering the conservative estimates of the parameters used, production by *Phaeocystis* may even be higher.
Several field studies have shown large seasonal variations of DMS in the southern North Sea, with a maximum in front of the Dutch coast during the *Phaeocystis* bloom. Our study has made it plausible that *Phaeocystis* itself plays an important role in this production of DMS.

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