Estuarine, Coastal and Shelf Science xxx (2013) 1–11

Contents lists available at SciVerse ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Impact of grazing management on silica export dynamics of Wadden Sea saltmarshes

Q4 F. Müller[a,*], E. Struyf[b], J. Hartmann[c], A. Weiss[c], K. Jensen[a]

[a] Applied Plant Ecology, Department of Biology, University of Hamburg, Ohnhorststr. 18, 22609 Hamburg, Germany
[b] Ecosystem Management Research Group, Department of Biology, University of Antwerp, Universiteitsplein 1C, 2610 Wilrijk, Belgium
[c] Chemistry of Natural Aqueous Solutions, Department of Geology, University of Hamburg, Bundesstr. 55, 20146 Hamburg, Germany

ARTICLE INFO

Article history:
Received 15 January 2012
Accepted 16 March 2013
Available online xxx

Keywords:
silica cycling
dissolved silica
biogenic silica
benthic diatoms
land use
Elymus athericus

Regional index terms:
Europe
Germany
Schleswig–Holstein
Wadden Sea
53°58′23.62″N
8°53′8.80″E
54°38′4.03″N
8°50′2.43″E

ABSTRACT

During periods of silica limitation, its supply from tidal marshes is important for the stability of estuarine and coastal food webs. Saltmarshes are highly dynamic, grass dominated ecosystems: their large area, high salinity and location imply that they could efficiently contribute to the buffering of silica depletion events in the coastal zone. As grazing management potentially alters vegetation and sedimentation dynamics in saltmarshes, it could have an indirect impact on silica cycling in these systems. In two saltmarshes of the Wadden Sea coast, concentrations of dissolved and biogenic silica (DSi and BSi) were measured in eight creeks in four seasons under different management conditions. Export rates were calculated using simultaneous discharge measurements. Mean annual DSi concentration in the seepage water was 338 ± 112 μmol l^{-1}. Ungrazed sites had significantly higher seepage water DSi concentrations than sites which were grazed by sheep. BSi concentrations were, in general, lower and more variable. DSi export rates from ungrazed sites (265 ± 155 μmol m^{-2} day^{-1}) were twice as high as from grazed saltmarshes (126 ± 137 μmol m^{-2} day^{-1}). DSi concentrations were among the highest values previously reported for saltmarshes and tidal freshwater marshes. Although differences in silica exports from grazed and ungrazed sites might be partly explained by silica uptake of benthic diatoms in the creeks, differences in hydrology appeared to be an overarching factor, controlling silica exports from Wadden Sea saltmarshes.

© 2013 Published by Elsevier Ltd.

1. Introduction

As an essential nutrient for diatoms, silica has a key function in the food web of coastal waters (Sullivan and Moncreiff, 1990). In pristine rivers, dissolved silica (DSi) is delivered to the coastal zone in excess over other nutrients as N and P (Justíc et al., 1995). Under conditions of eutrophication, however, DSi often becomes a limiting factor for diatom growth. In contrast to N or P, land-ocean silica fluxes are not anthropogenically enhanced (Anderson et al., 2002). On the contrary, constructional changes such as embanking and damming have led to increased sedimentation of biogenic silica (BSi) incorporated in diatoms, sponges or litter of vascular plants in the river systems leading to decreased land-ocean silica fluxes (Humborg et al., 2005). A depletion of DSi in spring and early summer, leading to limited diatom production, can change the species composition of phytoplankton communities (Hecky and Kilham, 1988) and produce harmful algae blooms, anoxic conditions and increased water turbidity. These changes constitute a disturbance of the aquatic food web by constraining the transfer of carbon to higher trophic levels (Anderson et al., 2002).

Tidal freshwater marshes are known to recycle BSi and to export relatively high amounts of DSi to the estuary (Struyf et al., 2005, 2006). BSi is deposited on the marsh surface during inundation events. It is mineralised and taken up by plants and benthic diatoms as DSi. After dieback of the vegetation, dissolution of plant BSi leads to high DSi concentrations in the soil water. DSi not taken up by plants can leach from the marsh soil and lead to an increase the concentrations in the adjacent water body. Even if, on a yearly base, many tidal freshwater marshes trap more silica than they release, it is clear that in times of silica limitation (spring and early

* Corresponding author.
E-mail addresses: frauke_mueller@gmx.de, frauke.mueller@botanik.uni-hamburg.de (F. Müller), eric.struyf@ua.ac.be (E. Struyf), jens.hartmann@uni-hamburg.de (J. Hartmann), andreas.weiss@zmaw.de (A. Weiss), kai.jensen@uni-hamburg.de (K. Jensen).

0272-7714/$ – see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.ecss.2013.03.010

UNCORRECTED PROOF

Please cite this article in press as: Müller, F., et al., Impact of grazing management on silica export dynamics of Wadden Sea saltmarshes, Estuarine, Coastal and Shelf Science (2013), http://dx.doi.org/10.1016/j.ecss.2013.03.010

summer), they are acting as an additional DSi source for the estuary (Struyf et al., 2005, 2006).

Saltmarshes might contribute even more to the supply of DSi to coastal waters than tidal freshwater marshes. According to Loucaides et al. (2008), higher pH and salinity are responsible for a fivefold enhancement of BSi solubility in seawater compared to freshwater conditions. Furthermore, saltmarshes are often more exposed to tidal forces during storm tides than tidal freshwater marshes. This enhances the supply of nutrients to the coastal zone in general (Odum, 2000) and is, therefore, also likely to increase the supply of silica. Finally, the global extent of saltmarshes is five times larger than that of tidal freshwater marshes (Mitsch and Gosselink, 2009) and the supply to the silica limited coastal zone is more direct since saltmarshes are located at the coast line. Vieillard et al. (2011) and Carey and Fulweiler (2013) have recently shown that significant amounts of DSi can be exported from North-American saltmarshes, corroborating this hypothesis.

As in tidal freshwater marshes, the vegetation in saltmarshes is dominated by grasses, which in general contain higher amounts of silica than most other plants (Epstein, 1994). Silica is taken up as monosilicic acid (H_4SiO_4) and precipitates in cell lumens, cell walls, and intercellular spaces as amorphous silicon dioxide (SiO_2NH_2O), also known as opal-A or phytoliths (Jones and Handreck, 1965). The solubility of this form of BSi (1.8 mmol l^{-1} at 25 °C and pH 8) is up to 17 times higher than the solubility of quartz (Fraysse et al., 2006). The soil of tidal freshwater marshes, saltmarshes and grasslands in general is highly enriched with phytoliths, which are the main source of pore water DSi in soils (Farmer et al., 2005). Grasslands are likely to play an important role in the global silica cycle (Blecker et al., 2006; Borrelli et al., 2008) as these systems cover more than 40% of the terrestrial earth surface (Melzer et al., 2010). Most grasslands are exposed to grazing, be it by wildlife or livestock which also enhances local nutrient cycling (Olsen et al., 2011). However, so far only one study has identified the impact of grazing on silica cycling on the ecosystem level (Melzer et al., 2010).

Long term grazing is known to change both biotic and abiotic conditions in saltmarshes (Bakker, 1985) and can consequently affect nutrient cycling. With intensive grazing, plant species composition changes towards species less sensitive to grazing and soil compaction by herbivores (Esselink et al., 2000). In recent decades, grazing was stopped in many saltmarshes at the Wadden Sea, allowing for the re-establishment of more natural dynamics in the system. In addition, at most sites, the artificial draining system was no longer maintained (Stock et al., 2005). This led to a shift towards taller species, more aboveground biomass, increased litter accumulation and on some marshes towards reduced species diversity (Bakker, 1985; Esselink et al., 2000). On many saltmarshes, abandonment led to a dominance of the grass *Elymus athericus* (Bockelmann and Neuhaus, 1999). Since this species is known to accumulate more silica in its tissue than many other saltmarsh plants (16.0 mg g^{-1} dry weight; de Bakker et al., 1999) and at the same time produces large amounts of biomass (Groenendijk, 1984), it can be hypothesised that silica cycling is indirectly affected by the changes in saltmarsh management.

This study aimed to determine the concentrations and export fluxes of DSi and BSi in creek water of saltmarshes and their seasonal patterns and to quantify the impact of saltmarsh management on silica concentrations and on silica exports to the coastal zone.

2. Methods

2.1. Study sites

The study was conducted in the Schleswig–Holstein Wadden Sea National Park in Germany (Fig. 1). The Wadden Sea, stretching from Denmark to the Netherlands, is a tidal-flat and barrier-island system. It includes the largest coherent area of tidal flats in the temperate zone (4700 km^2) and more than 400 km^2 of saltmarshes (Reise et al., 2010). Annual precipitation is ca.800 mm, and long-

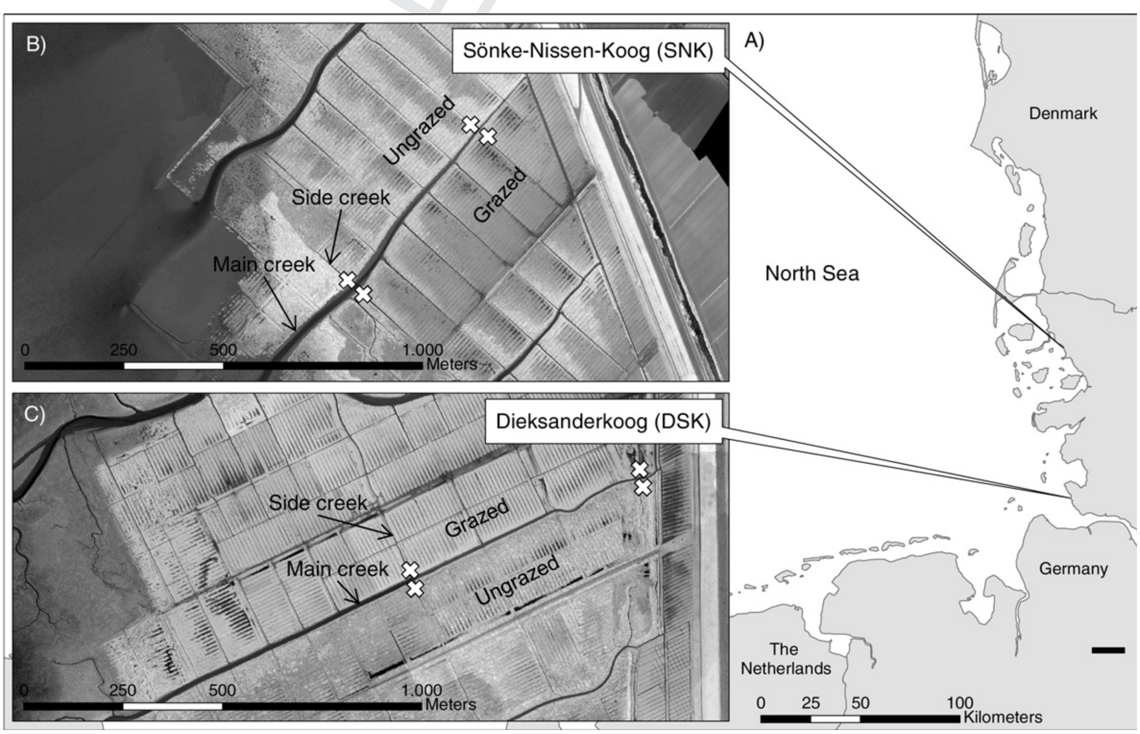

Fig. 1. A) Location of study sites in the German Bight. B) and C) aerial pictures of study sites; white crosses mark the sampling locations. Base maps: Amtliche Geobasisdaten Schleswig–Holstein, © VermKatV-SH.

Please cite this article in press as: Müller, F., et al., Impact of grazing management on silica export dynamics of Wadden Sea saltmarshes, Estuarine, Coastal and Shelf Science (2013), http://dx.doi.org/10.1016/j.ecss.2013.03.010

Download English Version:

https://daneshyari.com/en/article/6385111

Download Persian Version:

https://daneshyari.com/article/6385111

Daneshyari.com