Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2019-93-RC2, 2019


Biogeosciences Discussions
Open Access
EGU



# *Interactive comment on* "Warming enhances carbon dioxide and methane fluxes from Red Sea seagrass (*Halophila stipulacea*) sediments" *by* Celina Burkholz et al.

**Anonymous Referee #2**

Received and published: 17 September 2019

Review report of the paper entitled "Warming enhances carbon dioxide and methane fluxes from Red Sea seagrass (Halophila stipulacea) sediments" submitted by Celina Burkholz et al to Biogeosciences

Seagrass meadows, saltmarshes and mangroves are the "hot spot" blue carbon sinks and highly efficient in long-term carbon storage in the coastal marine ecosystems. Deterioration of these natural marine ecosystems through anthropogenic perturbation could change their carbon sinks efficiency and may contribute to climate change through re-emissions of locked carbon dioxide and other greenhouse gases. The warming-dependent emissions of metabolic GHG in the coastal ecosystems are likely



Printer-friendly version

Discussion paper

to vary for coastal sediment of different geological origin. It is expected that in situ temperature increase is particularly important in seagrass meadows which have high carbon sequestration with long-term storage capacity and trap organic matter from external sources. The extreme conditions in the Red Sea i.e. slower seagrass growth due to nutrient limitation and greater microbial degradation of soil organic carbon because of high temperature could be related to low Corg storage in the sediment compared to temperate meadows. This paper reports the results of the study on the response of sediment collected from two H.stipulacea meadows, S1 (22ËŽ56.775'N, 38ËŽ52.677'E) and S2 (22ËŽ54.742'N, 38ËŽ53.848'E) at Al Kharar, a lagoon on the Saudi coast of the central Red Sea in February-March 2018, in terms of air-seawater fluxes of CO2 and CH4 along with their isotopic signature from Red Sea meadows compared to for gradual increase of temperature from 25 ËŽC to 37 ËŽC and prolonged darkness. However, I had difficulties to understand certain sections of the manuscript including the methodology and discussion. Furthermore, the author did not address appropriately other important elements particularly the redox conditions, anthropogenic pressure in and around the the ecosystems (Seagrass and bare soil). The sediment in the present study is of carbonate (82.61-91.75% ) dominated. What constitutes the rest fraction (9-18%) of the sediment? It does not represent all types of sediment of different geological origin in Al Kharar lagoon. Previous reports (Serrano et al. 2018 Scientific Reports, 8:15037) indicate that soils in seagrass meadows in Saudi Arabia, Central Red Sea. are mainly constituted of clay and silt particles (37 $\pm$ 0.7% on average), with a relatively high abundance of very fine sands (21 $\pm$ 0.4%) compared to fine sands (16 $\pm$ 0.4%), medium sands (12 $\pm$ 0.3%) and coarse sands (14 $\pm$ 0.7%). Youssef & El-Sorogy, 2016 ( Arab J Geosci 9:474) showed that sediment textures consist of mud, gravelly sand, and sandy mud and organic matter in the sediment may also be derived from Mangroves which are common in Al-Kharrar lagoon between latitude 22° 45 and 23° 00 N and longitude 39° 00 and 38° 45 E. Why you have collected sediment from two H.stipulacea meadows only? Why the sediment of two H.stipulacea meadows showed high bulk density (1.1-1.28 g cm-3 ) relative to silt-clay sediment (

1.05 g cm-3 ) in seagrass meadows in Saudi Arabia, Central Red Sea Serrano et al. 2018 observed. The bulk density of carbonate sediment (carbonate 0.7 g/cm3) should be even lower than that of sediment containing mainly sand (1.586 g cm-3) and clay-silt ( 1.0 to 1.6 g/cm3). Organic carbon content of both vegetated (0.43 -0.55%) and bare (0.41 - 0.52%) carbonate sediment of H. stipulacea meadows is greater than the value reported for clay-silty sediment of other seagrass meadows (0.33%, Serrano et al. 2018 ). Why the production of H.stipulacea is high at the study site S2 compared to S1 and other seagrass meadows along the Saudi coast even though there was almost no available nutrients (N & P), and no difference in nutrients between S1 and S2. If seagrass detritus is the significant source of soil organic carbon, what is the source of organic carbon for bare sediment? Why vegetated and bare sediment of S1 showed no difference in soil organic carbon content? The $\delta$ 13 C-Corg showed depletion of 13C in comparison to leaf and both vegetated and bare sediment showed no significant difference of $\delta$ 13 C-Corg. Moreover, given $\delta$ 13C value of -7.96 $\pm$ 0.27 0/00 is lower than that of literature value for C4 plants -14 0/00. This needs clarifications. Use stable isotope mixing model to determine the actual contribution of seagrass on organic carbon content of the meadow sediment. CO2 fluxes were also 10-fold higher in vegetated compared to adjacent bare sediments, indicating elevated microbial remineralization rates in vegetated sediments. P 4: Before measuring fluxes, why the water inside the cores was replaced by fresh seawater ? Is it accumulated pore water ? Replacement of pore water saturated with CO2 and CH4 by fresh sea water may result serious error! Sediment core was incubated at one particular temperature and CO2 and CH4 concentrations were measured in 10 ml of head space air samples from each core at 0, 12hrs (light) and 12 hrs (dark). Considering, efluxes of 10,422 $\mu$mol CO2 m-2 d-1 and 88.11 $\mu$mol CH4 m-2 d-1, simple calculation shows after 12 hrs increased amount of CO2 and CH4 should be 37 $\mu$mol and 0.31 $\mu$mol, respectively. But standards (A: 750 ppm CO2, 9.7 ppm CH4, B: 250.5 ppm CO2, 3.25 ppm CH4) used before each (?) measurement of samples are all above those values. A plot of observed mixing ratio of CO2 and CH4 versus temperature should be given for better understanding.





Printer-friendly version

Discussion paper

The mean ratio of CH4/CO2 was found to be ∼0.008 which seems to be higher than the previous value reported for seagrass meadows (Halodule uninervis, Halodule pinifolia, Halophila ovalis, Halophila ovata, and Halophila beccarii ), Chilika Lagoon ( PLoS ONE 13(10): e0203922. https://doi.org/10.1371/journal.pone.0203922). The organic matter content was higher in S2 (vegetated 0.55%) than in S2 (bare 0.52%) by 5% . Is it below the error limit of its determination? How do you explain 6-fold CO2 and 100-fold CH4 greater emission in S2 (vegetated) than in S2 (bare) ? Provide a plot of observed CH4 concentration versus temperature . The Fig 2 D and E shows large scatter of data and drawing those straight lines have no use. The CH4 fluxes declined over time when the sediments were maintained at 25 ËŽC, both in vegetated ( Fig. 2D) and, less strongly, bare sediments. In contrast, CH4 fluxes tended to increase with temperature in vegetated (Fig. 2D) and bare (Fig. 2E) sediments gradually warmed from 25 ËŽC to 37 ËŽC, although it was not significant. Since the in situ redox condition of both water and sediment was not maintained during experiment that may affect the equilibrium between counteracting microbial processes of production and oxidation in the sediment. The study on the response of benthic net methane concentrations to higher temperatures needs also to take into account methane production rates, Q10 values, and community sizes of methanogens and methanotrophs in seagrass sediments . I believe that the manuscript needs significant revision before being considered for resubmission. Specific comments Abstract: In the first sentence please mention if Seagrasses are net source of CO2 and CH4. Line 17: “We detected distinct differences between vegetated and unvegetated sediments, with the vegetated sediments supporting 6-fold higher CO2 fluxes, and 10- to 100-fold higher CH4 fluxes” This is a confusing statement. What are the conditions for the high flux was not mentioned? Methodology “Assessment of carbon dioxide and methane air-seawater fluxes” This section is not clear. Please clarify the total number of samples collected from each core. Was there a periodic collection? Did the cores have seagrass in the top surface? What was the depth of the core sample? What were the criteria for fixing the light condition at 70 $\mu$mol photons m-2 s-1 and 200 $\mu$mol photons m-2 s-1 at different incu-

bation conditions? “The temperature in the second aquarium was increased at a rate of 1 ËŽC day-1.” Why this was done? Is this a natural increase (with 1day time) for the physiological adaptation by of seagrass? I wander how they have measured water-air flux from a system enclosed with sediment- water-air. Lots of Q10 values are available in the literature. Do those values agree with the present report? Results: The first sentence needs to be revised. Page 6 line 28: “There were no consistent differences in C, N and concentration in bare and vegetated sediments (Table 1).” Does it indicate limited influence of additional carbon storage in the seagrass sediment? “The mean C, N content is significantly lower in the seagrass leaf (Table 1) compared to global average carbon content of 35% (Duarte 1990; Fourqurean et al. 2012). There are several other seagrass sps apart from Halophila sp. in Kharar lagoon with considerable spatial variation sediment composition. Those Sps should also directly or indirectly affect the sediment composition. The sediment in the present study is manly composed of coral sand. Is it possible for the occurrence of such high concentration of OM in the sediment with no clay and silt? Page 6 Line 38: “The daily CO2 flux was up to 6-fold higher in vegetated compared to bare sediments, and tended to be generally higher in S2 compared to S1, where bare sediments showed net CO2 uptake, although differences were not significant” This result need to be discussed in details in the discussion section. Page 7 Line 21: “Despite CO2 and CH4 fluxes showing the same response to warming in both types of sediment, vegetated sediments held higher fluxes than bare sediments. The relationship between net CO2 and CH4 fluxes in bare vs. vegetated sediments showed that both bare and vegetated communities tended to act as net CO2 sinks at 25 ËŽC, but tended to act as CO2 sources at warmer temperatures (Fig. 3A), whereas net CH4 fluxes were 3- to 8-fold higher in vegetated compared to bare sediments. (Fig. 3B).” The organic carbon contents are comparable for seagrass and bare soil. Do the result indicate higher susceptibility of the seagrass soil carbon at a higher temperature? Apart from regulation by Seagrass, CH4 and CO2 efflux depend on the redoxcline which has not been highlighted in relation to the abundance of methanogens and methanotrops. In methodology of the incubation experiment it is





Printer-friendly version

Discussion paper

mentioned that ". . ..the water inside the cores was replaced by fresh seawater from the aquaria leaving a headspace of approx. 5 - 6 cm. . ..". Did this replacement change the redox condition of surface water? Discussion This section is inadequate and the observed results need more detailed discussions about the variations CO2 and CH4 fluxes at natural, high temperature and low light conditions. "Similar trends were seen by Garcias-Bonet and Duarte (2017) who reported an increase in CH4 fluxes with increasing organic matter content in Red Sea seagrass sediments." In the present study lower CO2 and CH4 fluxes were recorded from adjacent bare sediments with comparable Organic C content. Page 8 Line 24: ". . ..while the CO2 fluxes in vegetated sediments maintained at 25 ËŽC decreased over time." Why it was high initially and decreased gradually? explain. Line 30: "The presence of seagrass resulted in a higher organic matter supply to the sediments, favoring the presence of methanogens, which led to higher CH4 fluxes compared to those fluxes supported in bare sediments (Barber and Carlson, 1993; Bahlmann et al., 2015), consistent with the up to 100-fold higher CH4 fluxes supported by vegetated compared to bare sediments in this study." In the present study, soil organic C content in vegetated and adjacent bare sediment are comparable but CH4 fluxes are significantly different. Does the results (high emissions at S1 and S2) indicated direct CH4 emission from Seagrass? (pls see:Quist and Svensson, 2002, Vascular plants as regulators of methane emissions from a subarctic mire ecosystem, jgr, 107, NO. D21, 4580 and others) Effect of warming Page 8, Line 26 : "However, the fluxes maintained at 25 ËŽC were about 3-fold below those reported in a mixed Halodule sp. and Halophila sp. meadow in India (980 $\mu$mol CO2 m-2 d-1; Banerjee et al., 2018)." Is this the mean flux (the present value) or the least value recorded or the values represent during the end of the incubation at 25 ËŽC? In the previous sentence it was mentioned as "CO2 fluxes in vegetated sediments maintained at 25 ËŽC decreased over time"

Page 8, Line 40: "We also reported a 10-fold decline in CH4 fluxes over time for sediment communities maintained at 25 ËŽC, which could be attributable to increased sulfate reduction, reduced CH4 production or a combination of both. Methane is produced

under anoxic conditions in marine sediments, yet only a small portion is released, as CH4 production by methanogens is compensated for by CH4 consumption by sulfate-reducing bacteria (Barnes and Goldberg, 1976)." The soil redox conditions were not measured in this study. Please show some evidence of enhanced soil anoxicity which may have increased SO4 reduction. What could be the other reason/s of reduced CH4 production.

Conclusion

This section may be rewritten after revising the discussion section with few more synthesizing statements. Figure 2: what does the blue dots represent? Figure 3: ..... the dashed line indicates line 1:1, and dotted lines show lines 2:1, 4:1 and 8:1. Need to ve detailed

.

---

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2019-93, 2019.



Printer-friendly version

Discussion paper