



Introduction

The Paris Agreement established a global target of limiting surface temperature increases to below 2.0 °C above pre-industrial levels, requiring substantial CO₂ removal alongside emissions reductions (IPCC, 2022; Raven et al., 2024). CDR strategies include reforestation, direct air capture, ocean alkalinity enhancement, and ocean biomass sinking, which transports organic carbon (OC) to the deep seafloor for long-term storage (Raven et al., 2024). Anoxic basins such as the Black Sea may preserve OC through slow decomposition, but ecological consequences remain understudied. This study examines methane production and downstream pelagic impacts from anaerobic agricultural waste decomposition.

Results

1. Geological Context and Logistical Risk Factors
The Black Sea’s long water residence time and persistent anoxia support long-term OC preservation. Anoxic sediments contain substantially more OC than oxic sediments, indicating slower OM degradation (Raven et al., 2018). However, biomass sinking faces constraints including biomass availability, transportation, soil nutrient depletion, land-use competition, and environmental impacts (Raven et al., 2026).

2. Byproduct Formation and Environmental Impacts
Anaerobic decomposition involves DOM release, sulphate reduction, and methanogenesis, producing chemical byproducts (Raven et al., 2024). Modelling indicates that biomass addition could alter methane, sulphide, DOM, and pH concentrations in the Black Sea (Table 1). Comparable Cariaco Basin modelling predicts changes in methane, sulphide, ammonium, and pH (Table 2). Despite CH₄ production, less than 1% is estimated to reach the atmosphere due to anaerobic methane oxidation (Raven et al., 2024, 2026).

3. Chemical, Physical, and Ecological Effects
Biomass sinking could alter chemical conditions, sediment structure, microbial communities, and pelagic ecosystems (Raven et al., 2024; Roberts et al., 2026). Increased OC inputs may reduce aerobic habitat, while DOM and nutrient release could alter microbial communities and oxygen availability. However, ecosystem-level effects remain uncertain due to limited large-scale experimental evidence (Raven et al., 2026).

Discussion

The comparison of OC preservation in oxic versus anoxic waters supports the hypothesis that the Black Sea’s anoxic seabed could provide durable carbon storage (Raven et al., 2018, 2024). However, DOM release, sulphate reduction, and methanogenesis introduce chemical and ecological risks. Although modelled Black Sea impacts remain within natural variability, these projections depend on stable stratification and ventilation, which may change under future climate conditions (Raven et al., 2024, 2026). Potential effects, including benthic smothering, pH changes, and food-web disruption, also remain poorly validated at proposed biomass scales (Bauer et al., 2026; Roberts et al., 2026). Thus, biomass sinking shows storage potential but substantial ecological uncertainty remains.

Tables

Table 1
Modelled Chemical Impacts of Biomass Sinking in the Black Sea

CH ₄	Hydrogen Sulphide	Ammonium	pH
10 → 28–36 μM	80 → 262–375 μM	20 → 75–82 μM	Lipid-rich OC: –0.2; oxidised OC: –0.43 units

Note. OC = organic carbon. Input quantities differ by measure. Adapted from Raven et al. (2024) and Roberts et al. (2026).

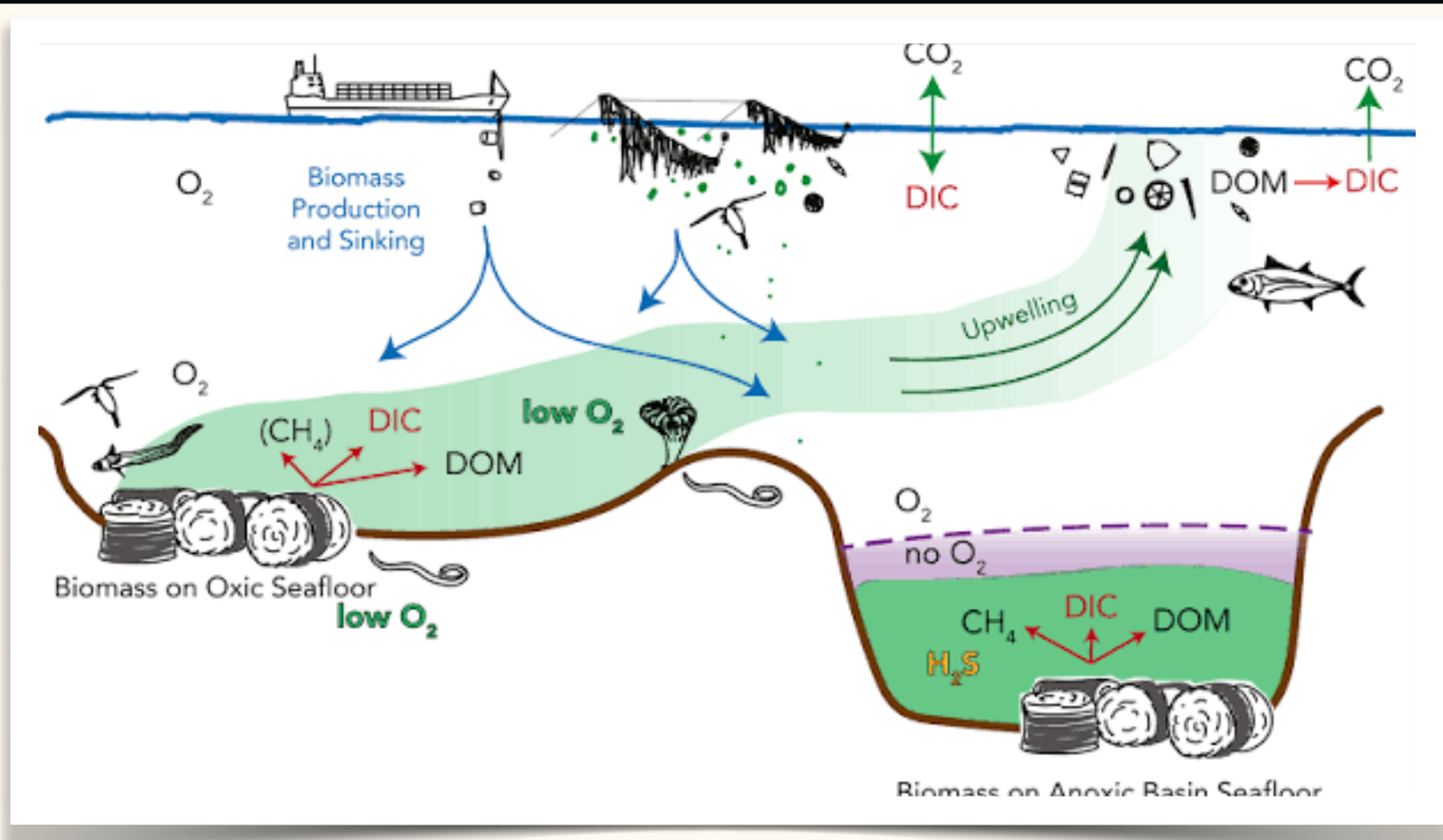
Table 2
Modelled Chemical Impacts of 2 Tmol OC Addition in the Cariaco Basin

CH ₄	Hydrogen Sulphide	Ammonium	pH
10 → 28–36 μM	80 → 262–375 μM	20 → 75–82 μM	Lipid-rich OC: –0.2; oxidised OC: –0.43 units

Note. Adapted from Raven et al. (2024).

Methods

A literature review was conducted using Google Scholar with predefined search terms on biomass sinking, carbon sequestration, methanogenesis, the Black Sea, ecosystems, and anoxia. Studies on seafloor methanogenesis or excess methane impacts were included, while oxic-basin studies were excluded. Data on methane, byproducts, microbial responses, and carbon storage were categorised and compared.



Note. Adapted from Raven et al. (2024).

Conclusion

Overall, anaerobic decomposition of sunk agricultural biomass is likely to increase CH₄ production and alter ecosystems, creating risks alongside carbon-storage potential. Current evidence cannot determine whether benefits outweigh risks. Further in situ studies should measure CH₄ production, OC degradation, and ecosystem responses before large-scale implementation.

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