Oil degradation rates in response to organic nitrogen input via phytodetritus in sandy permeable sands

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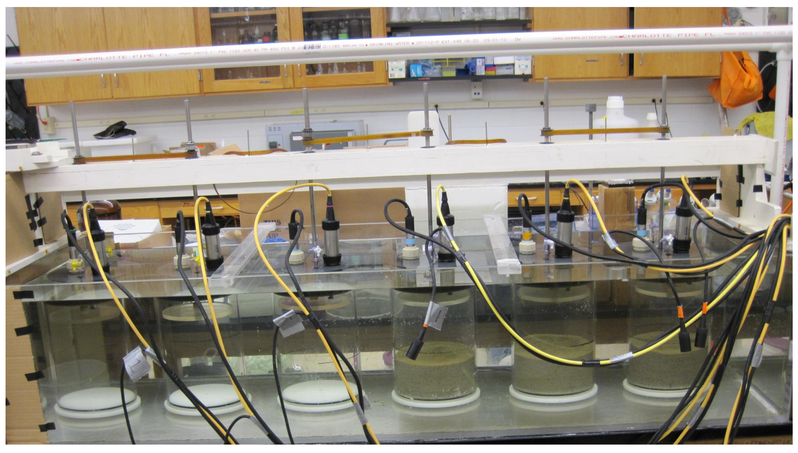


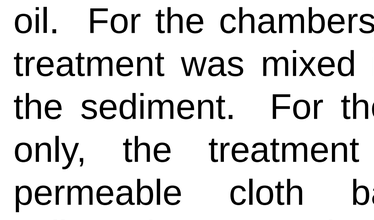
Abstract:
The aim of this project is to determine how burial of crude oil the different sediments along a depth gradient in the northeastern Gulf of Mexico from the shore to the deep sea affects the degradation of the oil. We compare the degradation of oil to the degradation of buried algae and buried oil with algae. The working hypotheses are that the degradation of oil is slowed down by burial and that burial of oil together with algae accelerates the oil degradation process. As a first step, we collected sand sediments from Pensacola Beach, Florida and incubated them in laboratory incubation chambers to determine the rate of microbial degradation of MC252 oil in these permeable sands. The majority of the degradation took place in the water column, supporting our hypothesis that the burial decreases the degradation rates 0.5%. Rates for the MC252 oil were enhanced with the addition of algae as a nitrogen source by 10% by 1.1. The next step will test cohesive mud sediments collected from deeper stations.

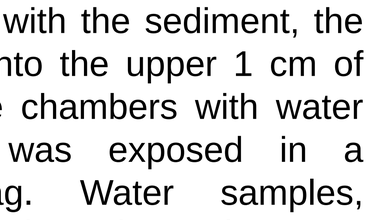
INTRO

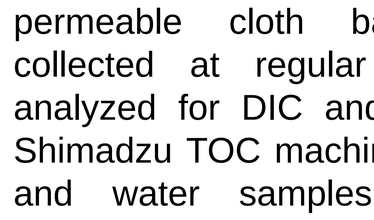
The Deep Water Horizon explosion and subsequent spill in April of 2010 released approximately 4.9 million barrels of oil over a period of 84 days. (Joye 2011). A large but not quantified volume of this oil reached the coast of the northeastern Gulf of Mexico where it contaminated beaches and shallow sublittoral sediments (OSAT reports). The fate of this oil is unknown. Previous research on oil degradation from this spill has focused primarily on the dry beach, the intertidal zone, or the water column. This study seeks to determine oil degradation rates in the sublittoral environment off Pensacola Beach. By measuring oxygen consumption and DIC production in oil contaminated water and sediment and compare measured rates to clean controls, we estimate oil degradation rates under near in situ conditions. Due to the shallow water depth in the West Florida Shelf, up to 50% of phytodetritus can settle to the bottom and becomes an important source of organic nitrogen to the sediments (Rabalais 2002). Past studies on the effect of Nitrogen fertilization on bioremediation of oil-contaminated sediments have shown contradictory results. We therefore also seek to determine the effect of organic nitrogen inputs to the degradation of oil.

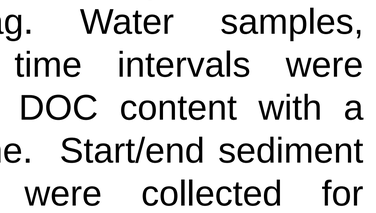
METHOD

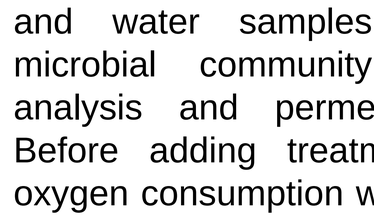
We used six 19 cm diameter by 30 cm polycarbonate benthic chambers submerged in a large tank filled with seawater (S=28, T=21C). Three of the chambers were filled with GFD 0.45 (insert pore size) filtered seawater, and the other three were filled with 10 cm of live sediment and GFD filtered seawater. The sediment was collected by divers at 20 meters depth off of Pensacola Beach, Florida. Seawater (S=28) was collected at the surface at the same location and stored in black sealed carboys. The chambers were sealed with a lid with a Hach® Rugged LDO1001 oxygen optode to measure dissolved oxygen, and a Turner Cyclops platform CDOM sensor to measure colored dissolved organic matter. Water could be extracted through two ports in the lid (one for fluid replacement). A stirring disk in each chamber, set to 20 rpms, ensured mixing of the enclosed water columns. Treatment #1 was an addition of 1 mL of the algae "Thalassiosira weissflogii". #2 was an addition of 1 mL of weathered MC252 oil and #3 was an addition of 0.5 mL of algae "Thalassiosira weissflogii" and 0.5 mL of weathered MC252 oil. For the chambers with the sediment, the treatment was mixed into the upper 1 cm of the sediment. For the chambers with water only, the treatment was exposed in a permeable cloth bag. Water samples, collected at regular time intervals were analyzed for DIC and DOC content with a Shimadzu TOC machine. Start/end sediment and water samples were collected for microbial community analysis and C/N analysis and permeability measurements. Before adding treatments to the system, oxygen consumption was monitored for 3 to 5 days to determine background activity.

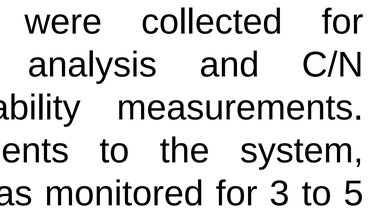












RESULTS

All three treatments increased oxygen consumption. Oxygen consumption rate was lowest with the algae only treatment #1 (-1.58 mmol L^{-1} m^2 d^{-1} water only chambers,,-1.55 mmol L^{-1} m^2 d^{-1} sediment chambers). The oil only treatment #2 (-5.23 mmol L^{-1} m^2 d^{-1} water only, -4.58 mmol L^{-1} m^2 d^{-1} sediment) and oil + algae treatment #3 (-5.77 mmol L^{-1} m^2 d^{-1} water only, and -4.57 mmol L^{-1} m^2 d^{-1} sediment) were almost identical in oxygen utilization.

DIC values were highest in #3 of the water chambers (6.72 mmol L^{-1} m^2 d^{-1}), twice as high as in the sediment chambers (3.27 mmol L^{-1} m^2 d^{-1}). DIC values were the lowest #1 (0.8 mmol L^{-1} m^2 d^{-1}) for the water chambers and sediment chambers (0.9 mmol L^{-1} m^2 d^{-1}). Treatment #2 had a production rate of 4.8 mmol L^{-1} m^2 d^{-1} (water only) and 2.8 mmol L^{-1} m^2 d^{-1} (sediment).

DOC values declined for all treatments. #1 had a consumption rate of -0.8 mmol L^{-1} m^2 d^{-1} (water) and -0.9 mmol L^{-1} m^2 d^{-1} (sediment) #2, 0.7 mmol L^{-1} m^2 d^{-1} (water), 2.04 mmol L^{-1} m^2 d^{-1} (sediment) and #3 4.2 mmol L^{-1} m^2 d^{-1} (water) and 0.9 mmol L^{-1} m^2 d^{-1} (sediment).

DISCUSSION

Based on the preliminary results from oxygen consumption, DIC production and DOC consumption, it appears that the addition of nitrogen via the phytodetritus has a positive effect on hydrocarbon degradation in the studied sediments. The higher oxygen consumption rate in the seawater only chambers likely is a result of the higher accessibility of the organic substrates to microbial degradation, supporting our hypothesis that the burial of oil slows its degradation rate. However, in the permeable sands, aerobic microbial degradation still can take place at the surface of the sediment where advective pore water flows transport oxygen to the embedded oil. In contrast to the water column, where algae may accelerate oil decomposition by providing rate-limiting nitrogen, algal addition to the sediment may slow oil degradation by consuming oxygen that is critical for the aerobic oil degradation. Our future research will address this discrepancy between water and sediment.

Acknowledgement
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