Using Clay to Bioremediate Oil Spills

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INTRODUCTION

A promising approach to reduce the destructive impact of marine oil spills is to enhance the rate of bacterial digestion using clay minerals.

Clays potentially aid bacterial activity in three main ways

- *i)* by aiding dispersion of the oil and increasing reactive surface area,
- ii) by providing nutrient-rich physical surfaces where the bacterial cells attach and feed, and
- iii) by adsorbing unwanted toxic substances (e.g. metals) that may inhibit bacterial activity.

Despite this general knowledge, the precise mechanisms of clay mineral-oil-bacterial interactions are not well understood and their application of clays for bioremediation purposes remains to be tested in the field.

In this presentation, the results of ongoing laboratory experiments are presented and compared for two basic systems:

- i) heavy beach oil from the Prestige (2003) spillage, N. Spain and
- ii) open marine oil from the Deepwater Horizon (2010) spillage in the Gulf of Mexico.

BEACH OIL OF THE PRESTIGE SPILLAGE (2003)

This case study investigated the influence of the Clay Mineral Society source clays on the bacterial digestion of Prestige beach oil after a 3 year period of treatment (Warr et al. 2009).

In this experiment, clay was added as a powder in equal quantity to the oil. The most successful clay minerals in stimulating the bacterial digestion of the Prestige oil were the Ca-montmorillonite and palygorskite samples. These samples also contained the highest concentration of bacteria cells (measured in colony forming units).

Over 93% of the total concentration of oil originally present was consumed in the presence of bivalent montmorillonite and presumably incorporated as biomass or released as CO_2.

The importance of exchangeable Ca^{2+} is emphasized by the extensive hydrocarbon breakdown (> 90%) observed with palygorskite and hectorite, both of which are abundant in exchangeable bivalent cations.

It is suggested that these bivalent cations aid bacterial activity by forming an ionic bridge between the negatively charged clay minerals and bacterial membrane, which allows for better transfer of nutrients from mineral to cell.

DEEP WATER HORIZON OIL FROM THE GULF OF MEXICO (2010)

The second case study simulated the addition of dried, thin filmed fertilized Fullers Earth clay to Deepwater Horizon oil of the Gulf coast, which is presented as a method of targeted biofertilization in open marine conditions.

In this case, the weight of the clay added was ten times less than that of the oil.

This palygorskite-montmorillonite clay mineral mixture, together with adsorbed

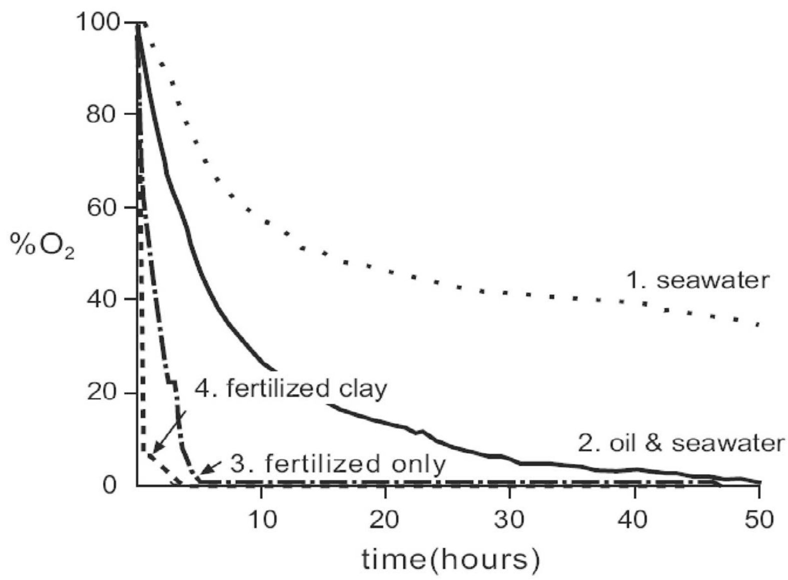

fig. 1. *O_2 respiration curves for Gulf coast samples. 1. Gulf coast seawater, 2. oil & seawater and 3. fertilized oil & seawater (fertilized only). 4. fertilized clay films oil & seawater (clay-treated). O_2 is expressed in % calculated from the difference between initial and measured O_2 concentrations (ml/l). Samples were measured after ca. 4 months of reaction time and 24 hours after last O_2 flush.*

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N and P fertilizer, filming additives and organoclay, were engineered to float on sea-water, attach to the oil, and slowly release contained nutrients that ultimately speed up the rate of bioremediation and subsequent dispersion.

The simulation study of microbe activity in weathered Gulf coast oil indicates that fertilized clay treatment enhanced bacterial O_2 respiration by more than 50 times compared to untreated conditions and acted 4 times faster than straight fertilization (Fig. 1).

Such treatment offers a way to more effectively fix the fertilizer to the spill in open waters and thus can significantly shorten the life span of marine oil spills.

Overall, whether applied as powders to the beach environment or as dried thin films in open marine conditions, clay mineral based materials represent a diverse natural source bacterial nutrients that can aid the digestion of unwanted oil.

REFERENCES

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