Identifying a link between cable bacteria and hydrocarbon degradation in polluted marine sediments

Dr Ugo Marzocchi’s research focuses on the main factors that regulate macronutrient cycling in benthic zones, both in natural and artificial settings. His work concentrates on better understanding cable bacteria, which are microorganisms able to mediate electric currents in sediments. Dr Marzocchi is dedicated to understanding the way cable bacteria behave in nature, their metabolism, distribution and geochemical impact, and learn how to use cable bacteria as a bioremediation tool for the degradation of contaminants.

Crude oil, or unrefined petroleum, consists of a mixture of hydrocarbons. It maintains its liquid form both in underground geological formations and when extracted and brought to the surface. Human activities heavily rely on the use of petroleum for energy and transportation. Unfortunately, handling such large amounts of oil at a global scale has had serious repercussions on the environment. Major incidents, involving a transport vessel capsizing and releasing large quantities of fuel into the ocean, plus spills/seeps arising from small and large maritime transport and from naval scraping centres, add to the illegal disposal of waste rich in oils, affect the inhabitants of the ocean, the wildlife that preys on it, the fresh and saltwater bodies and the coastline that surround these. Over time, the petroleum hydrocarbons residues will accumulate and sink to the bottom of the waterbed, giving rise to a thick hydrocarbon-rich sediment. This affects the existing benthic community’s (group organisms living together at the bottom of a seabed, river, lake, or stream) ecosystem, by altering the temperature, pH, light penetration, dissolved oxygen availability and nutrients concentration.

CURRENT CLEAN-UP METHODS

Conventionally, large pools of crude oil spills are contained using booms, long floating barriers which are placed around the spill to stop it from spreading further. Different clean-up methods are used, including skimming the oil layer from the surface of the water, using for instance disks and floating drums, setting the oil alight, and using chemicals to break down the oil into smaller compounds to be later consumed by naturally occurring microbes. These methods, however, require calm waters in order to be somewhat successful, and they come with certain downsides. In the case of skimming, the procedure is time consuming and residues too small to be collected will remain dispersed in the waters. Burning the spill contributes to emissions and can be dangerous to the wildlife if out of control. Lastly, chemical dispersing introduces nasty and harmful chemicals to the environment which can be toxic to the wildlife and coastal inhabitants. Instead, degrading the hydrocarbons by environmentally friendly means, for example by using naturally occurring microorganisms, could be a viable solution.

CABLE BACTERIA: STIMULATING HYDROCARBON DEGRADATION

A good example of this is the research conducted by Dr Ugo Marzocchi and his collaborators at Aarhus University in Denmark and at the National Research Council of Italy in Rome, who have taken up the challenge of looking for bio-based methods to increase the degradation rate of hydrocarbons using microorganisms. The research team first had to understand what basic principles needed to be addressed in order to degrade the concentration of hydrocarbons within the sediment. It is important to note that hydrocarbon degradation is limited by the availability of oxidants, whose concentration is higher in layers of the sediment closer to the water compared to deeper within the sediment. By increasing the level of oxidising agents (such as sulphate), it is possible to speed up the degradation process, perhaps by means of a natural catalyst or an expeditor, such as cable bacteria.

Let’s take a quick step back and get to know cable bacteria, the protagonists of this article. Cable bacteria are generally found in reduced sediments within freshwater, saltwater lakes, and marine habitats. They were first discovered in 2010, within sediments of the Aarhus Bay, and subsequently detected in other marine and freshwater sediments throughout the world. Thanks to their unusual constitution, they have been able to adapt and survive in marine sediments rich in hydrocarbons, where their presence led to investigating their possible applications in bioremediation.

Dr Marzocchi and his collaborators assessed the role of cable bacteria by simulating a hydrocarbon degradation environment and compared the results to a method called Snorkel.

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Behind the Research

Dr Ugo Marzocchi

Dr Marzocchi identified a link between cable bacteria and hydrocarbon degradation in polluted marine sediment.

Personal Response

Do you envisage the fabrication of large benthic mats using cable bacteria, that could be used to treat medium to large oils spills?

The possibility to fabricate benthic mats is fascinating, but surely challenging. As an alternative, the growth of cable bacteria could be triggered in situ via providing favourable conditions (e.g., supplying suitable electron acceptors such as oxygen or nitrate to the bottom water). Thanks to their unique metabolism, cable bacteria will extend the effect of the treatments to centimetres depth into the sediment. Further, an early diagnosis of the presence of cable bacteria in contaminated sites could help decision makers to evaluate, within cost/benefit analysis, whether to implement expensive mitigation measures or let the system recover naturally.

The results showed that a combination of Snorkel and cable bacteria yielded the highest degradation rate. Could this be attributed to the two working together in a synergist way?

Within the timespan of our incubation, the rate of alkane degradation of the combined cable bacteria and Snorkel treatment equalled the sum of the treatments where the two ‘systems’ were applied individually, therefore suggesting a mere additive effect. However, our geochemical data suggest that in the presence of the snorkel, cable bacteria expand their volume of influence and possibly their life span. The question on the synergy therefore remains open. A recent study reported the ability of cable bacteria to attach to solid electrodes. Although we could not find evidence of this phenomenon in our experiment, we cannot exclude this possibility.

Research Objectives

Do you envisage the fabrication of large benthic mats using cable bacteria, that could be used to treat medium to large oils spills?

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Detail

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Bio

Dr Ugo Marzocchi is an Assistant Professor at Aarhus University. He is interested on the main factors that regulate the cycling of macronutrients (nitrogen, phosphorous, sulphate, iron) in benthic systems. He is particularly interested on the geochemical impact and ecology of electro-active bacteria, and their potential in technological applications.

Funding

• European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie actions. Project ENIRIS (grant 656385)
• Danish National Research Foundation (grant DNRF104)

Collaborators

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References


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