Can bacteria combat oil spill disasters?

September 26 2013, by Tilo Arnhold

Teams of international scientists have decrypted the effectiveness of two types of bacteria, which could be used in the future to help combat oil spill disasters. According to a report written by scientists from the Helmholtz Centre for Environmental Research and the Helmholtz Centre for Infection Research in the peer-reviewed journal *Applied and Environmental Microbiology*, Alcanivorax borkumensis converts hydrocarbons into fatty acids which then form along the cell membrane. New insights on the bacteria Oleispira antarctica are important to understand their adaptation to low temperatures and could help in mitigation strategies for oil spills in polar seas or the deep sea, according to comments made by an international team in the peer-reviewed journal *Nature Communications*.

Until now, chemicals have often been used to clean up oil disasters, to break up the oil/water emulsion, making oil more soluble and thus removing it from the surface water. According to data from the US Environmental Protection Agency (EPA) around seven million litres of such chemicals were used to combat oil pollution in the Gulf of Mexico, resulting from a spill of about 700,000 tons of crude oil into the sea from the offshore oil drilling platform "Deepwater Horizon" in 2010. Some of the most well-known of these were dispersants with the brand name Corexit—developed following the notorious tanker accident of the Exxon Valdez in Alaska in 1989. These substances have been heavily criticised however because of their side effects on humans and the environment. In the context of the EU-project BACSIN, scientists from different countries have therefore been investigating alternatives. "One approach for example could be to stimulate oil-degrading bacteria in

their growth or for example by making them easier to use by freeze-drying so that they can be sprayed more easily than powders over the oil slick", explains Dr. Hermann J. Heipieper from the UFZ. "However, there are still lots of details that require fine-tuning before the day arrives when they can be used to combat damage from oil spills. The precautionary principle should therefore be given priority. No matter how concerted efforts are, nature will never completely return to its original state, not to mention the fact that the mitigation of environmental damage from oil spills is much more costly than its prevention."

Oil-degrading bacteria are not a human invention. In fact, they have been around for millions of years. The only thing that is new is the quantity of oil being spilt in the sea from oil disasters. Therefore, science has been looking into novel ways to accelerate natural degradation processes. One focus has been on hydrocarbon-degrading bacteria - so-called marine obligate hydrocarbonoclastic bacteria. These specialists at degrading hydrocarbons in marine ecosystems are able to degrade aliphatic hydrocarbons and use them as a source of energy. These bacteria are common in sea water all over the world, even if only in small quantities. If they come into contact with crude oil, then their population increases exponentially. A kind of bloom is formed, similar to those that we are familiar with from marine algae blooms. And yet, in spite of their important ecological meaning, still relatively little is known about the processes taking place in the cells of these bacteria. Headed by Dr. Hermann J. Heipieper, researchers from the UFZ have therefore been conducting detailed physiological and genomic analyses of the two reference strains of this group of bacteria (Alcanivorax borkumensis and Oleispira antarctica) that is tremendously versatile. This can be seen in particular by changes to the cell surface, by the way in which biologically oxidized aliphatic hydrocarbons are built into the cell membranes and by the regulation of genes to adapt to environmental stress.

Alcanivorax borkumensis is a marine bacterium, owing its name to the place where it was discovered – the island of Borkum (in spite of its worldwide distribution). It is considered to be one of the most important organisms with the ability to degrade oil spills in marine systems. Nevertheless, up until now there had been a lack of information on the growth and physiology of these bacteria in relation to hydrocarbons with different chain lengths. The recent investigations found that the bacterium were particularly effective at processing alkanes with carbon chain lengths of between 12 and 19 carbon atoms. "The cell growth confirmed that this bacterium is not only able to take up the intermediates of fatty acids in its own body but also to convert them", explains Heipieper.

By contrast, for the significantly colder polar seas or the deep sea Oleispira would be the more suitable bacterium. It can survive at temperatures around 5 degrees Celsius that are typical for example on the seabed of the Gulf of Mexico. With eleven protein crystal structures it has the largest quantity of structures under the cold-loving microorganisms and it clearly has more negative charges at the surface than microorganisms in moderate temperatures. Even if most of the enzymes of this bacterium no longer work optimally under cold weather conditions, they still work sufficiently to accelerate growth and outdo other competitors, if a hydrocarbon diet from crude oil suddenly becomes available. The persistence of these bacteria is proof of their ecological competitiveness in cold environments, therefore making them good candidates for the development of biotechnological solutions for oil pollution mitigation in polar regions. The new insights about the two bacteria are a small, but important step forward in the search for alternatives to the toxic dispersants that have been used so far.

More information: Naether D.J., Slawtschew S., Stasik S., Engel M., Olzog M., Wick L.Y., Timmis K.N., Heipieper H.J. (2013): Adaptation of hydrocarbonoclastic Alcanivorax borkumensis SK2 to alkanes and

toxic organic compounds - a physiological and transcriptomic approach. *Appl. Environ. Microbiol.* 79:4282-4293, in press. DOI: 10.1128/AEM.00694-13
dx.doi.org/10.1128/AEM.00694-13

Kube M., Chernikova T.N., Al-Ramahi Y., Beloqui A., Lopez-Cortez N., Guazzaroni M.E., Heipieper H.J., Klages S., Kotsyrbenko O.R., Langer I., Nechitaylo T.Y., Lünsdorf H., Fernández M., Juárez S., Ciordia S., Singer S., Kagan O., Egorova O., Petit P.A., Stogios P., Kim Y., Tchigvintsev A., Flick R., Denaro R., Genovese M., Albar J.P., Reva O.N., Martínez-Gomariz M., Tran H., Ferrer M., Savchenko A., Yakunin A.F., Yakimov M.M., Golyshina O.V., Reinhardt R., Golyshin P.N. (2013): Functional genome analysis of Oleispira antarctica RB-8, a key oil-degrading bacterium in cold and deep marine environments. *Nature Communications* 4:2156, 23 July 2013. DOI: 10.1038/ncomms3156