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Microbes offer natural alternative to clean up oil spills: Researchers

Their findings could inform development of greener solutions for future pollution events

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Chemicals are usually sprayed on oil slicks in water after an oil spill to break up the pollution, but new research in Singapore has found that nature has its own tool to combat the contamination – an army of micro-organisms.

This finding could inform the development of more environmentally friendly clean-up materials, said Professor Stephen Brian Pointing of the National University of Singapore (NUS), who led the research. It also highlights the importance of the ocean's microbiome, and why its health should be considered even when designing coastal protection strategies, he added.

In June 2024, Singapore experienced one of its worst oil spills, when more than 400 tonnes of oil leaked into the nation's southern waters after a dredging boat hit a bunker vessel.

Prof Pointing's team, who had already been working on research on micro-organism diversity, saw the opportunity in the crisis to learn more about how bunker fuel impacts the microbial environment.

They collected samples of sand from Bendera Bay on St John's Island, which had been intentionally left uncleaned so scientists could study the impacts of the spill.

Within the bay, they obtained sand from sites that were completely stained with oil, and from areas where no oil slicks were visible.

Using metagenomic sequencing, a method that enables scientists to characterise all genetic material in a sample, the researchers identified the types of micro-organisms found in the samples.

The team found that areas more highly impacted by the oil spill had a greater diversity of oil-eating bacteria and, in particular, one called *Macondimonas diazotrophica*, which has the ability to break down oil in low-nutrient environments like tropical beaches.

This was the first time that this bacterium has been documented in Singapore's waters, Prof Pointing said. It was previously found in the beaches off Florida after the Deepwater Horizon spill in the Gulf of Mexico.

Oil hydrocarbons – chemical components of oil – were undetectable in the samples collected from Bendera Bay six months after the incident.

Overall, the researchers found that there was a proliferation of 41 species of bacteria primed to break down oil. Such bacteria are usually not detected in clean sand, Prof Pointing added.

The oil-degrading microbes were also observed to persist six months later, even after oil in the spill samples had been broken down. This suggests that the Republic's coasts will retain the ability to break down oil, fortifying their response to future spills, he said.

Two species of archaea – single-celled organisms that are similar to but distinct from bacteria – were also detected six months post-spill.

Archaea do not break down oil, but are found in healthy coastal shorelines and are hence a good indicator of recovery, Prof Pointing explained.

He said: "Our study showed that in areas that are difficult to access for clean-up operations after an oil spill, nature can lend a helping hand and do the job for us given sufficient time."

In the immediate aftermath of the 2024 oil spill, the authorities used chemical dispersants to break the oil into smaller droplets that could be mixed with water.

These dispersants only "sink" the oil without chemically degrading it, potentially giving rise to deposits on the seafloor that take a long time to break down. Thus, while dispersants swiftly remove oil from the ocean's surface, they could inadvertently harm the environment, Prof Pointing said.

He added: "The oil is toxic to marine animals and, if ingested by invertebrates or small fishes, can in turn negatively implicate the bigger sea animals that consume them."

But while the breakdown of oil by microbes is more environmentally friendly, the process is time-consuming.

Allowing the oil to remain on the ocean's surface would put both aquaculture farms and recreational beachgoers at risk, Prof Pointing said, which left Singapore with little choice but to use dispersants.

Alongside other scientists, Prof Pointing and his team are tapping their findings to engineer bulwarks and solutions for future coastal pollution events.

For example, they are developing a microbial cocktail to clean up contaminated sand removed from the Republic's shores in 2024. The cocktail would likely contain several species of micro-organisms, as each degrades only a certain component of the oil, but is unable to break it down completely on its own, Prof Pointing explained.

He said: "We're hoping to better understand how these microbes mechanistically break down oil, and devise a way to do some off-site treatment."

Prof Pointing is also advocating the inclusion of structures that facilitate the growth of biofilms – communities of living microbes embedded in a slimy matrix – in Singapore's efforts to protect its coasts from sea-level rise.

Structures with rough surfaces, for example, are easier for biofilms to attach to.

And those with angles and contours may prevent microbial communities from washing away during storms, making them more likely to persist and help in clean-up during future oil spills.

"In engineering our coasts, it's not just about biodiversity and climate change resilience – pollution is also an issue," Prof Pointing added. "Although acute pollution events don't happen very often, they can potentially be catastrophic, and that's why it is a good idea to include (safeguards against) them in our resilience plans."

Associate Professor Huang Danwei, a marine biologist from NUS who was not involved in this study, agreed that ensuring high microbial diversity is important, as it is often a key element of a healthy ecosystem.

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