Big technological leap in treating PCB contamination in the environment

September 16 2014

A team of researchers from the National University of Singapore (NUS) Faculty of Engineering have developed a novel approach that could greatly enhance the effectiveness of destroying polychlorinated biphenyls (PCBs) in the environment. They discovered three powerful bacteria from a genus called Dehalococcoides which can degrade PCBs. In addition, the researchers also developed an effective method of culturing these PCB dechlorinators in large quantities to enhance their degradation efficiency.

Working with A*STAR's Genome Institute of Singapore (GIS), the team was able to identify the functional genes responsible for breaking down PCBs. With these research findings, it is now possible to design and engineer methods which can rid our environment of harmful PCBs more effectively. Their findings were recently published in the prestigious US journal, *Proceedings of the National Academy of Sciences* (*PNAS*).

PCB contamination and challenges posed to environment

PCBs are synthetic organic chemical compounds of chlorine and biphenyl. They have been widely used as coolant fluids in many electrical products. However, they are toxic and exposure to PCBs has been known to show symptoms almost immediately. Though PCBs are no longer used (they have been banned since the 1970s), they are virtually indestructible and can possibly remain in the environment forever. Hence they continue to contaminate rivers, lakes and harbours worldwide, posing a threat to human and ecosystem health.

There have only been seven known enzymes associated with Dehalococcoides found to have confirmed function on chlorinated compounds. The NUS-GIS research team is proud to add the three new bacteria to the list – each with distinct specificities.

An in-situ microbial detoxification strategy, which involves applying microbes directly to break down (dechlorinate) PCBs on-site, would be very effective for PCB bioremediation. However, these microbes are extremely hard to culture, hence limiting efforts to characterise them for such applications.

Currently, the only treatment is capping or dredging and landfilling the PCBs. An example is the ongoing SuperFund project to dredge the upper Hudson River to remove PCBs which has already cost nearly US$1 billion. In this regard, the novel technique developed by the research team to culture PCB dechlorinators could pave the way for alternative, and possibly more effective, methods of degrading PCBs on-site.

Novel substrate for culturing PCB dechlorinators

Associate Professor He Jianzhong, who is from the NUS Department of Civil & Environmental Engineering, explained, "While the scientific community has found out that certain bacteria can dechlorinate PCBs and make them more susceptible to oxidation, it was not until three decades ago that some were identified. However, challenges still remain in growing these organisms in quantities that will make an impact. Their low biomass has also prevented us from studying closely the process, especially in identifying the enzymes responsible. Furthermore, as PCBs are extremely insoluble, they are unsuitable as substrates for culturing the helpful bacteria."

To overcome this problem, the NUS team came out with an alternative substrate called Terrachloroethene (PCE) which can be used to boost the cell numbers of PCB dechlorinators.

"This discovery is a quantum leap forward in our understanding of microbial PCB dechlorination and hence open up new possibilities of developing more effective ways of destroying PCBs in our environment," said Assoc Prof He.

Genomic technologies to the fore

Dr Niranjan Nagarajan, who leads the research at GIS, said, "Through synergy generated from traditional culture techniques combined with state of the art genomic technologies, we could successfully cultivate and characterise three PCB dechlorinating microbial strains. From these efforts, we were able to be the first to identify the functional genes responsible for breaking down PCBs. These genes could be very useful as biomarkers for monitoring PCB bioremediation."

Assoc Prof He added, "Finding useful bacteria can be tough. Our work shows how advanced genomic technologies can be combined with culturing to sift through bacteria in the environment and find the gems. This is a big step forward in the development of in-situ microbial detoxification technologies for PCB bioremediation."

These discoveries promise to move the bioremediation technology for PCBs into the realm of reality because for the first time, bioaugmentation is feasible. The impact of this outstanding research is tremendous, which makes in-situ bioremediation possible by saving significant amount of time and labor. Future research will be focused on application of genomic technologies for in-situ degradation of PCBs and other halogenated compounds.

Provided by National University of Singapore