Well-fed bacteria a faster cure for diesel leaks

Scientists at the Division of Water Resources in Perth are working with naturally-occurring bacteria to speed the breakdown of organic contaminants. **Liana Christensen** reports.

To a layperson 'organic contamination' may sound like a contradiction in terms. Isn't organic supposed to mean wholesome?

Not always. Petroleum, chlorinated hydrocarbons and munitions residues all are classified as organic contaminants. Leaked, spilled or disposed of improperly, these compounds can pollute groundwater and soils.

The risk of such pollution can be reduced in a number of ways.

Monitoring the state of underground storage tanks, or improving their design, may lessen the amount of leakage into groundwater.

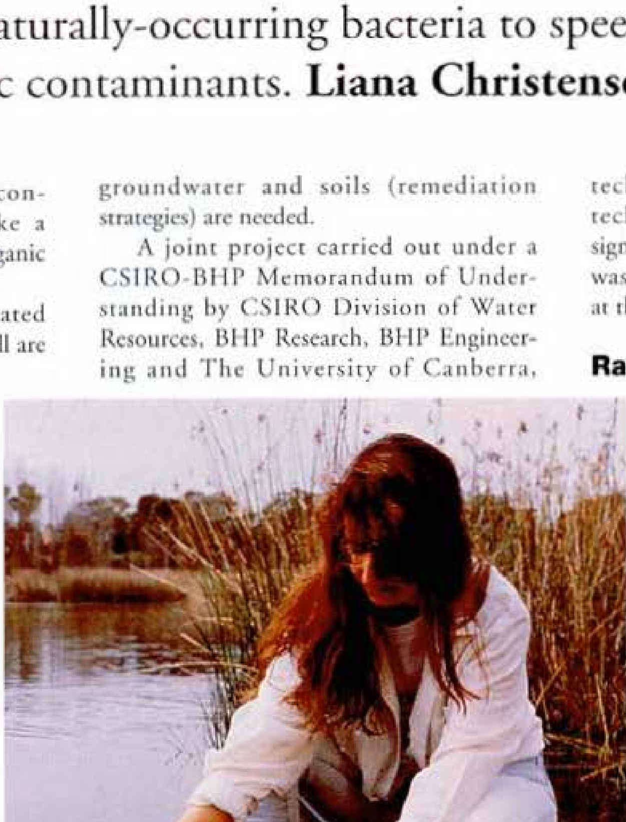
Proper planning should disallow the placement of petrol stations and particular industries over vulnerable aquifers.

In some cases, it may be possible to substitute a less toxic compound for a commonly used chemical, or at least reduce its use. The solvent trichloroethene (TCE), for example, is used less widely than it once was.

We can be thankful for the restricted use of this chemical, because studies carried out on a TCE plume in the groundwater under the Perth suburb of Jolimont showed that this particular compound does not biodegrade readily there, neither is it easily adsorbed onto soil particles.

Although TCE has been shown to biodegrade in other parts of the world, where the groundwater has perhaps a different chemistry, persistent toxins are obviously best kept away from groundwater. In instances where leakage has already occurred, however, and to safeguard the continued use of organic contaminants, methods of cleaning polluted groundwater and soils (remediation strategies) are needed.

A joint project carried out under a CSIRO-BHP Memorandum of Understanding by CSIRO Division of Water Resources, BHP Research, BHP Engineering and The University of Canberra,



Measuring the rate at which microbes consume oxygen has been simplified with the development by CSIRO and Greenspan of a durable and reliable dissolved oxygen probe. Yvette Oliver from CSIRO's Division of Water Resources demonstrates the instrument which uses a diffusion cell to measure oxygen in gas, surface water and groundwater.

indicates that in some cases such clean-ups may be possible.

With the cooperation of BP Oil, two trials were carried out at Kwinana in Western Australia. Using a number of techniques and specially developed technologies, the researchers achieved significant degradation of diesel fuel which was contaminating soil and groundwater at the site.

Rapid remediation

Project leader, Dr Greg Davis, is a typical 'quiet achiever', but his voice carries a note of excitement when he describes the successful completion of five years' hard work. His research team managed to break down the diesel at rates well above any previous studies, and five to 10 times higher than the background (natural) rates. It's a result worth getting excited about, because it may enable the cleaning up of severe diesel fuel contamination in a period of one-and-half to four-and-half years.

According to Davis, the broad idea of the remediation experiment was to stimulate bacteria living beneath the soil surface to use the diesel fuel as a carbon source, and to do so in such a way that the degradation rate was rapid enough to be economically viable.

It sounds simple enough, but months of laboratory experimentation, field studies and modelling were needed to prepare for the on-site trials.

The first step was to accurately map the contaminant which was spread over several hundred square metres, in a one-metre-thick layer, four metres below ground. Once this was done, the position of boreholes needed to carry out the remediation strategy were pin-pointed.

The remediation strategy itself involves two phases: mounding and drawdown. The 'mounding' phase involves raising the groundwater level and pumping dissolved nutrients in through boreholes. Computer simulations of pumping regimens are used to determine the right velocity and direction to ensure the nutrient reaches the contaminant.

In response to the added nutrients, indigenous bacteria (predisposed to consume diesel) rapidly increase their rate of diesel consumption. Thus the degradation process gathers speed.

The 'drawdown' phase of the strategy is then initiated. Water is pumped out through the boreholes so that the thin contaminated zone is above the water line. The site is then aerated, which maintains the heightened level of diesel consumption. (Microbiological degradation is accelerated when oxygen is present).

The first on-site remediation trial lasted six months and was followed by laboratory and field work, and further modelling, to fine-tune the strategy. Using soil cores from the site, the researchers established that the nutrients did indeed hasten biodegradation, and that nitrogen (as ammonium) and phosphorous (as phosphate) worked synergistically. The second trial, completed in 1995, took nine months.

The rate at which the microbes consume oxygen relates directly to the rate of biodegradation. Measuring this process has become much simpler with an oxygen monitor developed by the CSIRO team. This instrument uses a diffusion cell to measure oxygen in gas and water. When linked to an automatic data logger it provides immediate feedback about the state of affairs underground.

Similar probes are being developed for automatically measuring volatile organic compounds in collaborative research through the Cooperative Research Centre for Waste Management and Pollution Control Ltd, under the leadership of Dr Chris Barber. These devices are a marked improvement over the old system of taking water or soil core samples back to the laboratory for analysis. The economic viability of enhanced biodegradation relies on these kind of innovations.

Davis and his colleagues are also applying their expertise to munitions residues in groundwater within fractured basalt, under another Memorandum of Understanding with the Department of Defence.

From field and laboratory work relating to a site under an old munitions factory in Melbourne, answers to a number of key questions are being sought.

Is the natural degradation rate of the munitions (explosive) residues sufficiently fast?

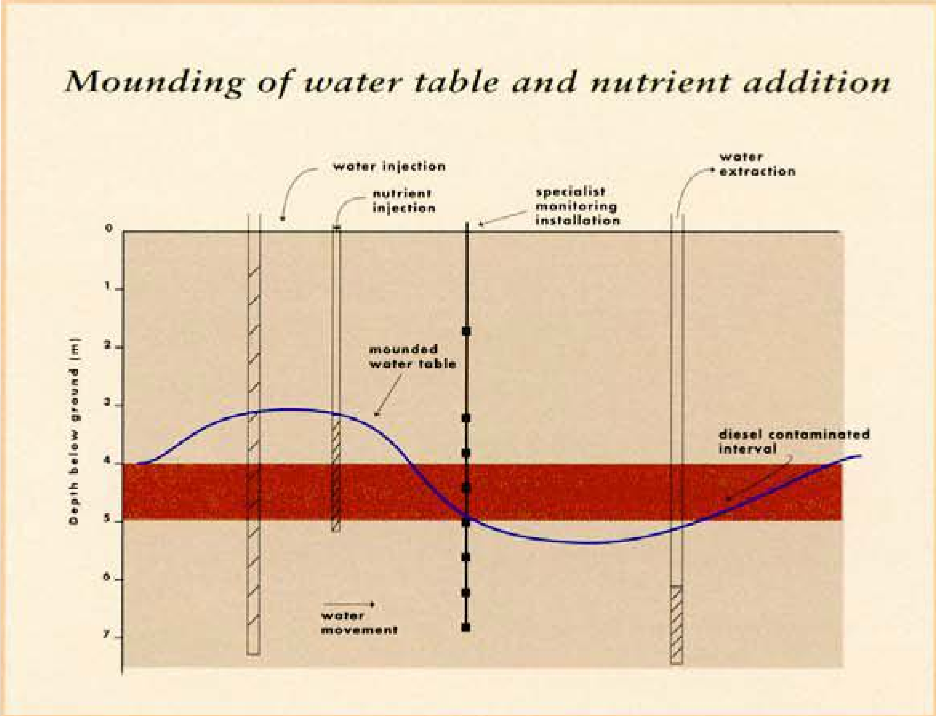
If it disappears, is it truly biodegrading or simply being adsorbed onto the weathered basalt?

What is limiting biodegradation - the nutrients nitrogen or phosphorus? (Results seem to indicate that phosphorus is not a limiting factor.) Is it perhaps oxygen or a carbon source?

Where will the contaminant plume go in the long run, if left unchecked?

Finding answers to these questions opens up the possibility of enhanced biodegradation of munitions residues as well.

Bioremediation offers exciting potential to work with nature to cure industrial disease. Now that's an organic concept!



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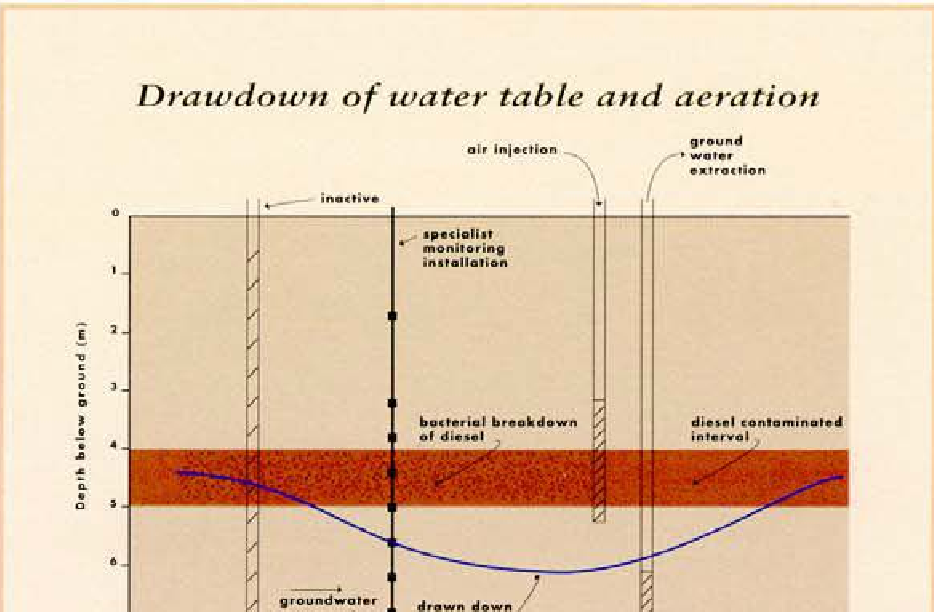

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