Tony Collings and Paul Gwan examine the transducer and horn that generates the ultrasonic wave in a slurry. CSIRO Industrial Physics

Sound treatment for polluted sites

Australian researchers have discovered that pesticides and other undesirable pollutants in soil can be rapidly destroyed by exposing them to ultrasound. They hope their work will mean that soil from chemically contaminated sites can be cleaned and rehabilitated by use of powerful ultrasonic waves in purpose-built treatment plants.

With legislation covering contaminated sites becoming tighter worldwide, scientists are focussing attention on preventing and deactivating pollution on industrial and agricultural sites. Australia has close to 100 000 contaminated sites which are a real and costly headache, threatening both human and environmental health. The same properties that have made many synthetic chemicals useful to industry also make them a severe environmental risk: their stability means they persist in the environment, they can travel long distances in air and water, they cling to soil and sediments and they can bio-accumulate in food chains.

Locking up contaminated sites means that valuable land or real estate is foregone, while remediation has often simply meant removing the contaminated soil and burying it somewhere else. Now, laboratory studies by Tony Collings, Paul Gwan and Andrea Sosa Pintos, at CSIRO Industrial Physics, have led to a better way to cleanse contaminated soils – using acoustic energy.

'An ultrasonic wave is a high-frequency sound wave beyond human hearing, and in our research we use 20 kHz, which is just above the normal human hearing limit of 15 kHz for young people … at least those without a sound system in their car,' Collings says.

'As the high-power sound wave moves through a liquid, it generates little bubbles, known as cavitation bubbles. When these bubbles collapse or implode, high pressures and temperatures – up to 1000 atmospheres and more than 5000 Kelvin (about 4727°C) – occur at a local microscopic scale. These extreme conditions cause chemical reactions that modify chemical compounds, much like an incinerator,' he said.

'The key to our invention is that, if we have a pollutant in a solid-water mixture and subject the slurry to powerful ultrasound, the nasty compounds, which tend to stick to the solid particles, are "chemically decomposed", that is, broken down to harmless products. The pollutant, located at the solid interface, takes the brunt of the shock wave when each bubble collapses … or to put it another way "gets the living daylights blasted out of it!" We essentially use the bubbles as micro-reactors.

'Even better,' says Collings, 'the slurry as a whole stays below 60°C, despite the cavitation turmoil within, and this quenching prevents the formation of other toxic by-products like dioxins and the reformation of the original pollutants during the process, a serious drawback with some other technologies.

'We are also looking at restoring, if not improving, the health of the soil after treatment to ensure it is in top shape.'

Collings told *Ecos* that his team is achieving better than 90 per cent destruction of persistent organic pollutants in just a few minutes of treatment, and as high as 99 per cent destruction in 10 minutes, using ultrasound in laboratory experiments. 'Now we're working with a pilot plant, using a battery of ultrasound devices, able to treat up to half a tonne of contaminated soil a day, using just four kilowatts of power, and we can ramp up to two tonnes per day.

'Assuming successful scale-up, high-power ultrasound will be considerably cheaper than the $70 charge, in Australia, merely to dump contaminated soil as scheduled waste, or AU$165 in the United Kingdom,' Collings says. 'Our method is also very much cheaper than competing destructive technologies which cost several hundred to several

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thousand dollars per tonne.'

The ultrasonic method, which is covered by international patents, has other advantages in addition to the high destruction rates, lack of dangerous breakdown products and low energy demands. A treatment plant capable of processing a million tonnes a year could be made compact enough to transport to trouble spots for on-site remediation. It also can be switched on and off in an instant (making possible use of off-peak power) and the polluted slurry can be moved around hydraulically, something to which Australian minerals companies are quite accustomed.

A wide range of toxic compounds has been destroyed by the CSIRO researchers using the technique, indicating its versatility. Their lab hit list includes: PCBs (polychlorinated biphenyls), PAHs (polycyclic aromatic hydrocarbons), and a number of organochloride pesticides and herbicides, such as DDT, lindane, endosulfan, atrazine and 2,4,5-T – some seriously poisonous compounds.

'We're really excited about the potential of the technology and we're confident about the science,' Collings says. 'Contaminated sites are purportedly a multi-billion dollar market, so we'd like to see the technology stay in Australia.'

The team is now seeking commercial interest and partnerships in an effort to secure the future of their initiative with its many potential international applications.

● **Steve Davidson**

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