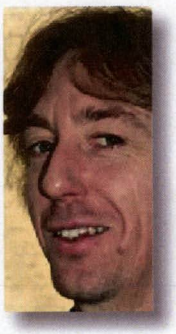
Modified air compressor with windmill chain driving mechanism.



by Johan van Leeuwen

"Intermittent air injection actually has positive effects on the bio-stimulation process."

Green Remediation

"Zero emission" *in situ* soil remediation

Green remediation. We can do it!

About two years ago I got a brochure in the mail for a solar heating system; "green showering for everyone at home," it said. I realised you can produce a significant amount of energy this way, but (so far) this technology hasn't been used for remediation of contaminated sites.

I started to think about green technologies like windmills and solar cells. Would it be possible to integrate these at long-term *in situ* remediation sites. An idea was born that led to a green remediation initiative at the Dutch railways foundation for remediation (SBNS).

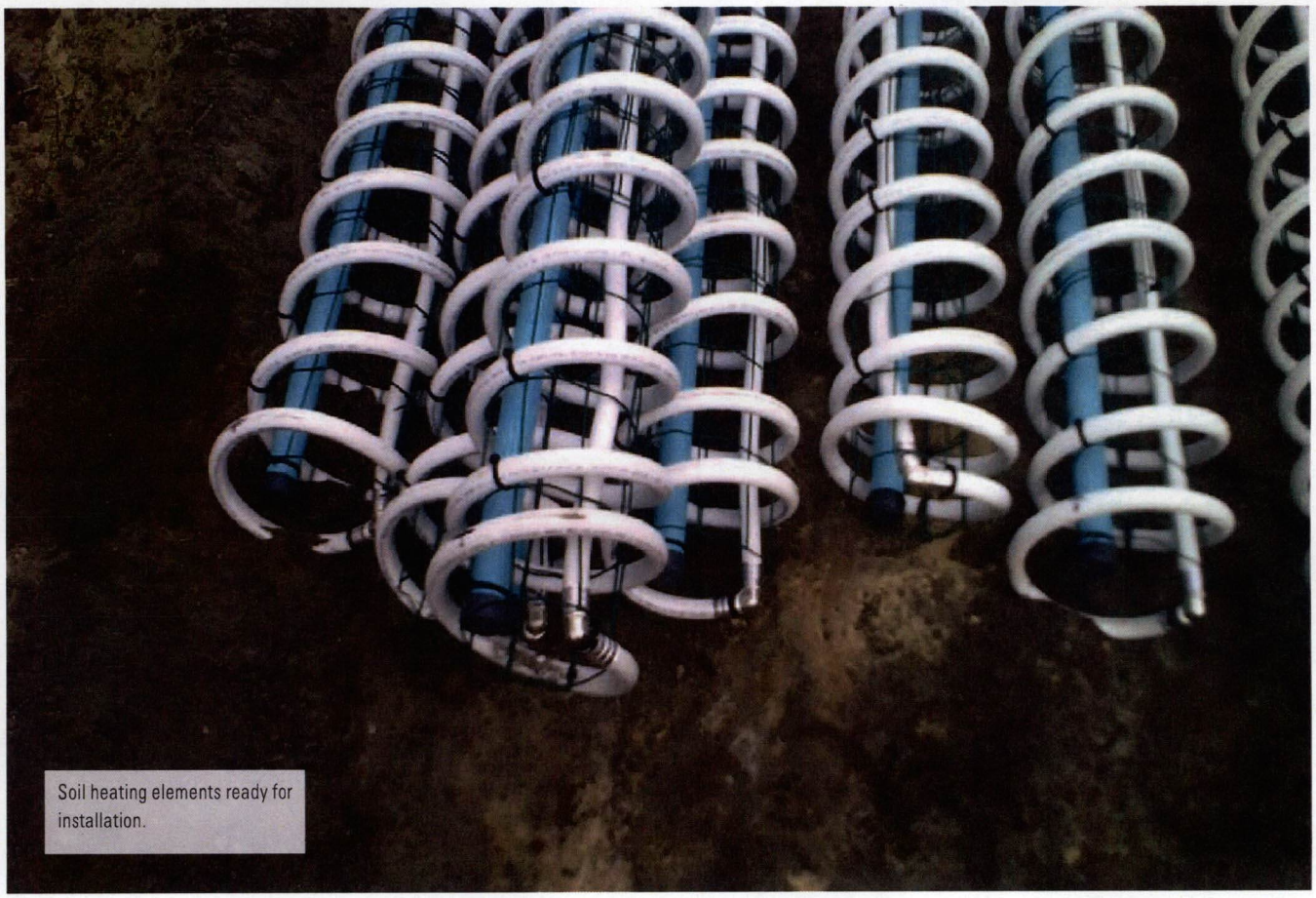
THE PROJECT AND REMEDIATION

The project site is located in a village called Bilthoven, in the centre of the Netherlands. The site, which is near a railway station, has soil polluted with mineral oil. The contamination is present from a half meter to approximately nine meters below surface level. (Contamination in the vadose zone, from the surface to two meters below ground, was excavated in 2011.)

The pollution deeper than two meters is present in what's called the "saturated zone." The approach to this zone was different: instead of excavation, it was decided that nature would be used to the greatest extent possible, to achieve a more sustainable solution. A brainstorming session was organized with the consultancy Tauw and contractors from HMVT; the session produced 13 leading ideas which where then assessed for feasibility.

So, how do we make use of nature in remediation?

Bacteria present in soil can break down pollution like mineral oil, if circumstances are right. If there's enough oxygen and nutrients, the bacteria convert the oil into carbon dioxide and water.



Soil heating elements ready for installation.

At this site, the natural circumstances weren't ideal, so the project managers knew they'd have to assist the bacteria in doing their job. An *in situ* system warms the soil and delivers oxygen via compressed air, and liquid nutrients are pumped in.

At first the consultants proposed air stripping (with large amounts of air forced into the soil). But this idea was replaced with bio-venting and soil warming (with bio stimulation in mind). Bio-venting uses much less energy compared to air stripping; however, warming the soil consumes even more energy.

What to do? A green approach was needed to solve this.

GREEN ENERGY SOLUTIONS

The consultants and contractor designed a system to provide all the energy required for the site remediation utilising a solar heating system, solar cells and a windmill. (This is a Dutch project after all!)

The solar heating system warms the soil to stimulate bacteria growth. The windmill acts as a direct air compressor (an innovation). Solar panels where installed to generate electricity needed for the small pumps and electrical components of the installation. To extract gases from the soil, a chimney was placed next to the windmill (so a ventilator wasn't needed anymore).

Conventional soil remediation concepts use a lot of energy, usually provided via fossil fuel consumption or electricity from the grid. In contrast, the Bilthoven site works on the principal of using energy when it's available. When the wind blows, compressed air is produced and injected; if there's no wind, injection is suspended temporarily. On a cloudy day the soil gets warmed less by the solar heating system; on sunny days there's more warming.

When the soil is warmed from 10 to 20 centigrade the bacteria activity doubles, solubility increases, and volatilisation goes up as well. This means the pollution mobilises from the soil to the water phase, and becomes available for the microorganisms.

At another railway site a conventional remediation with soil heating was applied; the warming went up to 35 centigrade, but costs rose steeply as well, which is why this approach is rarely used. At the Bilthoven project site, the solar heating system reduced costs by more then 80 per cent. However, the remediation took five years instead of one.

OVERCOMING TECHNICAL CHALLENGES

To efficiently warm the soil, floor heating tubes were used (commonly used in Dutch homes). The tubes were, for instance, wrapped around a PVC well or

> "In October 2012 the project won a sustainable land-use prize at the UIC Railway Congress."

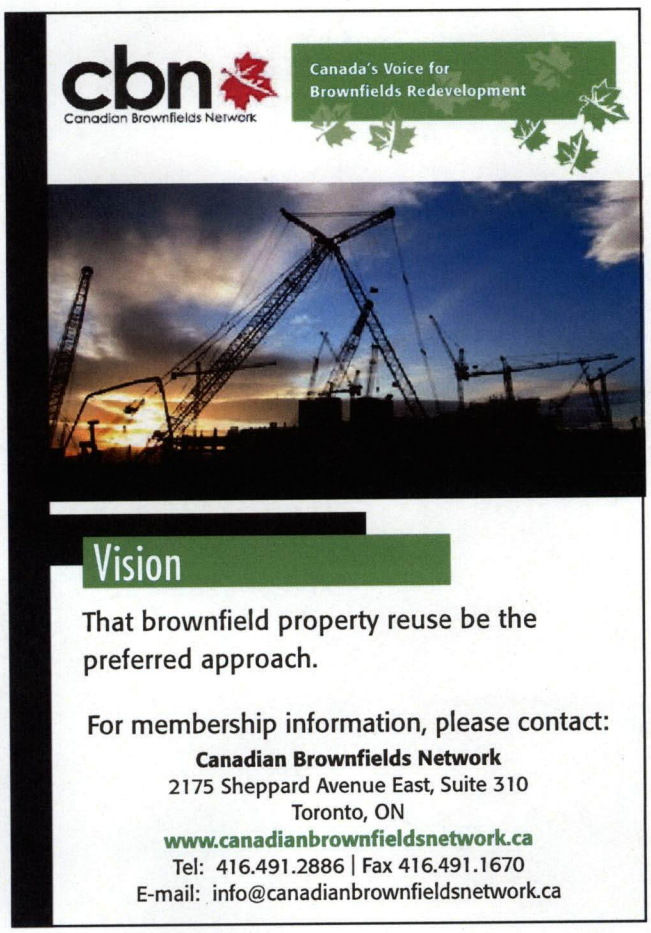
similar. Then the pipe with tubing was drilled into the soil (like an ordinary well) — this functions as a simple heat exchanger. When using a well wrapped with tubing, the heat exchanger can also be used as a nutrient-injection well. (A 15 centigrade increase in temperature was achieved in the soil at a distance of 1.5 to two meters from the heat exchangers.)

To produce compressed air, a windmill was installed at the site. Research was conducted on minimum, maximum and average wind speed during the year at the

specific location, to determine how much wind could be converted into compressed air (with a windmill 15 meters high). The windmill dynamo was replaced with an air compressor driven directly at the axle.

The research showed there would be no compressed air available 22 per cent of the time. About a third of the time an average amount of compressed air would be produced, and 45 per cent of the time the system would produce its maximum of compressed air (for optimal oxygen saturation in the soil). At other sites the project managers learned that intermittent air injection actually has positive effects on the bio-stimulation process, meaning there would be enough compressed air for an optimal remediation process.

It's worth noting that even in Holland erecting a windmill in an urban area isn't easy, and can face public opposition. It took some time to obtain a license for the windmill at the Bilthoven site from the community council. (Projects in some jurisdictions may have to consider producing electricity with solar cells or using a conventional air compressor.)

The green remediation project at the Bilthoven site was a very inspiring one, proving the viability of some new concepts. In October 2012 it won a sustainable land-use prize at the UIC Railway Congress. The jury stated the concept should be applied on sites elsewhere. Green projects like this one can match the costs of conventional approaches, though one has to take into account that the windmill and solar cells are not fully depreciated in the five-year duration of this project, but over a period of 15 to 20 years. This will work fine for some projects, though perhaps not all. **HMM**

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