PROFITING FROM THE EARTH

BY EMILY CHOW

R
os of crops typically de-
note farming activity. But
some types of plants, when
cultivated, are able to harvest
or mine for minerals. This is
called phytomining.

Unlike conventional mining,
where the earth is dug out and
the metals are refined, phytomining uses
plants to accumulate metals,” says Dr
Elie Gebeshuber, a professor at Vienna
University of Technology’s Institute of
Applied Physics, who has been work-
ing in Malaysia for the last six years.

Plants called hyperaccumulators
have the ability to extract and accumu-
late metals from the soil. They are able
to absorb high amounts of heavy met-
als — 10 to 100 times the level found
in most species — without suffering phytotoxic effects.

This is a natural occurrence in such plants. According to Gebeshuber’s re-
port, titled “Rare Materials Synthesis
from Heavy Metal Industry Effluents
with Bioremediation and Phytomining:
Biomimetic Resource Management
Approach,” many heavy met-
als are essential or beneficial for the
growth and metabolism of plants, but
are dangerous if found in high concen-
trations. These include cobalt, copper,
iron, manganese, nickel and zinc.

There are several hypotheses about
why some plants are able to absorb
metals from the soil, one of which is
that the toxicity of the metals act as a
deterrent and protect the plants from
being eaten. It is also natural for soil
to contain metals, sometimes in highly
dissolved forms.

“In phytomining, you cannot think of
it as plants taking out little nuggets of
metal from the ground. What they do
instead, and what conventional mining
cannot do, is take out highly dissolved and
diluted metals from the soil. The metals are not
concentrated,” explains Gebeshuber.

So, plants with their root system,
by taking water from the soil, also take
the metals in soil with metal ions in
their bodies.”

Different plants absorb different
types of minerals or metals. According
to Gebeshuber’s report, there are 440
types of plants, called “metallophytes,”
which are nickel hyperaccumulators. Other plants accumulate other metals,
such as cadmium, copper, stron-
ium, sodium, thallium and zinc.

When the metals ions have been
extracted and concentrated in the
plant’s tissue, they are harvested, dried,
ground and burnt as part of the metal
extration process. After the plant or
biomass is burnt to produce bio-oil,
it is treated with chemicals to get re-
finned metals.

There are two types of hyperaccu-
mlation in phytomining — natural
and induced. Natural hyperaccumula-
tion occurs when plants absorb heavy
metals as a normal function of their
growth. Induced hyperaccumulation
occurs when chemicals are added to
the soil to manipulate the environment
so that the metal becomes soluble. This
is used in phytomining elements such
as gold because plants do not naturally
accumulate them.

The chemical catalyst needed for
phytomining gold is cyanide — a po-
sotous chemical compound usually
used in insecticides, pest control and
conventional mining methods to ex-
tract gold and silver. While there are
environmental concerns about adding
cyanide chemicals to the soil, certain
plants such as soybeans naturally emit
cyanide and can be planted near
copper hyperaccumulators to dissolve the
gold in the soil. This is a more environ-
mentally friendly way to phyto mine gold.

ADAPTATION AND
COMMERCIAL USES

While different hyperaccumulators ab-
sorb different minerals and metals, the
plants are location-specific and need
a suitable climate to grow and thrive.

Phytomining takes one crop season
(three to six months) to accumulate
dependent, on the plant. The amount
of metal absorbed depends on the
types of hyperaccumulation, where
the metal is poured into the
bioremediation, or the process
of using hyperaccumulators
to clean up soil that has been
contaminated by metals.

If there is lead in the soil, for
example, many plants cannot
grow anymore because lead
pollutes the earth and plants are
very sensitive to lead,” explains Dr
Gebeshuber, a professor at Vienna University of Technology’s
Institute of Applied Physics.

“In this case, you can plant a
lead hyperaccumulator in the soil
to drag the lead out of the soil.
Then, you take away the plant
and dispose of it. There are
many plants that accumulate lead, one of
which is the sunflower, which
also can accumulate copper.
This is done wherever you have metal
mining.”

According to Gebeshuber, the practice of phytomining has been around
for many generations, thus exactly when
it was discovered cannot be
determined. The first recorded
field trial for phytomining, however,
were carried out at the US Bureau of Mines in Nevada, USA, in 1956. A nickel
hyperaccumulator was used in soil
containing 1.5% of the metal, well below the economic
range for conventional mining.

THE PHYTOMINING OPERATION

Crop grown on soil containing
metal concentration too low
for conventional exploitation
Possible production of electricity
Small volume of plant ash (bio-oil)
containing high concentration
of target metal
Plant material burnt

Gebeshuber believes these num-
bers are productive enough for min-
erial extraction. While it can never be
comparable to the production rates of
conventional mining, phytomining allows
metals to be extracted from
soils that are considered uneconomic
by conventional mining methods, or
for phytoremediation purposes (the
restoration of polluted soil).

Another limitation of phytomining
is that hyperaccumulators are only
able to extract metals on the surface
of the soil. “Mines go down hundreds
and hundreds of metres, taking out
all the soil and metals. But for plants,
their roots only go down to two to
four metres,” says Gebeshuber.

Despite the limitations, one man
is attempting to make phytomining
work on a commercial, albeit small,
scale. Dr Chris Anderson, principal
scientist at Croesus Projects Ltd, has
spent the past decade developing gold
phytomining in China, Mexico and
Indonesia.

He founded Croesus, an environ-
mentally focused education and in-
vestment consultancy, in 2005. The
company focuses on geochemistry,
with a focus on environ-
mental pollution related to min-
ing and industrial operations, and
specific competencies in environ-
mental impact assessments and phy-
toremediation.

Later, Croesus became a founding
investor in New Zealand-based gold
phytomining company Tiaki Inter-
national Ltd.

"While Tiaki continues to work
on gold phytomining, primarily
in North America, my main focus
with Croesus is applying gold and nickel
phytomining technology to develop-
ing countries,” says Anderson. "The
primary aim here is remediation and
growth. From now on, the future will
be a lot greener.“

In order to carry out phytomining, one
first needs to obtain land with the
target metal. The soil needs to have
a certain level of metal as that the
operation is economically
viable. This may be hard to come by as-existing
mine wastes are tightly controlled
by mining companies.

“There is plenty of nickel- and gold-rich soil worldwide, but not much platinum-
and palladium-rich soil. For this reason, large-scale platinum and palladium mining has nev-
er been considered viable,” as we cannot get access to the resource,” says Anderson.

Once land is obtained though, the
operations are simple enough. The
hyperaccumulators are farmed, and
this process is not costly as there
is not a lot of intellectual property
in the area of farming. The risks faced
in this venture would be agricul-
tural-related — drought, crop failure and
floods. It gets tricky when the crops
are ready for harvesting. The crops or
biomass need to be processed so the
metals can be recovered. This can be
done immediately or they can be stored
for as long as needed. Anderson says
this is an expensive process, as there
is no good and proven technology yet to carry it out in an efficient and economical manner.

Significant investment is needed to develop a good processing system for nickel- and gold-rich biomass. There’s also need to think any economically profitable phytomining operation will be possible until this is done,” he says. Anderson was the one who pioneered gold phytomining in 1998 when he discovered that a chemical called thiocyanate caused plants to absorb gold. While he says plants can be made to accumulate just about any metal, the practicability of this technology depends on cost. Generally only the semi-valuable metals (like nickel, silver and copper) and valuable metals such as gold and platinum are realistic targets.

“For nickel, probably 2000 kg per hectare would be feasible. My target for gold continues to be 1kg per hectare. I think these levels would sustain a business,” he says.

“But note that these must be considered as part of the package, that it also creates jobs and provides opportunities for agricultural training. The question is, where will we find the source or the land, that will support these yields?”

Anderson is realistic about what phytomining can and cannot achieve. It cannot be directly compared with conventional mining because mining companies take into consideration the volume of minerals produced, which phytomining never does. Phytomining can produce 10,000 tonnes of metal from a hectare of plant biomass over one crop season, while large-scale mining processes the same amount of rock in hours.

“What phytomining can do, however, is sustain a community — by providing an economic incentive to mineral whose land is subjected to illegal gold mining owing to the residue left behind. There is usually plenty of gold left in mining wastes, Anderson says, so the revenue generated from “farming” this waste pays for the extraction of the metal and the management of pollutants that would otherwise be discharged into the soil and water. “I am supporting several small operations in Indonesia, but these are not large commercial operations. They are artisanal and small-scale gold mines in Lombok, Sumbawa and Java,” he says. “In collaboration with the University of British Columbia in Vancouver, Canada, we have been working to apply gold phytomining to this same scenario in Ecuador and Peru.”

Reiterating that phytomining has a strong social and environmental purpose, Anderson says that despite receiving about 15% of the total revenue generated from “farming” this waste pays for the extraction of the metal and the management of pollutants that would otherwise be discharged into the soil and water.

“I believe the future of phytomining is in the developing countries, where it can be used to generate or supplement community income. Harvesting metal from poor or degraded soil is perhaps a better option than growing food,” he opines.

“So, to large mining companies, the value of phytomining is in the use of the plants to clean up the mess, to remediate waste land or to site in mine closure. Mining companies are not receptive to the phytomining aspects of the technology. But if the technology could help them achieve environmental targets, then they would be.”

A Malaysian miner who is asked whether his company would be interested in phytomining, agrees that the technology has potential. “Significant investment is needed to develop a good processing system for nickel- and gold-rich biomass. If prices go down, mining companies will struggle to make money from low-grade resources, making it available to phytomining,” he says.

“I think there is tremendous potential for phytomining in Southeast Asia, but this requires collaboration between Western science and technology and Asian investment and business.”