ENVIRONMENTAL DAMAGE DURING GEOTHERMAL WELL TESTING

d'E. Charles Darby

Kingston Reynolds Thom & Allardice Limited (KRTA)
Geothermal Power Consultants
Auckland, New Zealand

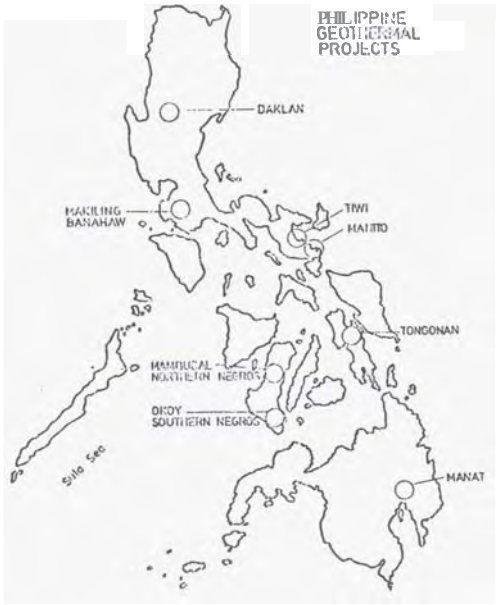
ABSTRACT

In the early stages of developing some of the large Philippine geothermal fields it was usually impractical to provide injection wells, particularly in remote parts of the field, and medium term test effluents were therefore discharged to the environment. Thus two possible pathways of damage existed; discharge of steam to atmosphere and discharge of separated wastewater via a pond to the nearest watercourse.

ATMOSPHERIC DISCHARGE THROUGH SILENCERS

Separated steam and non-condensable gases are discharged from silencers at rates up to 50 kg/s and carry with them droplets of geothermal water containing the full range and concentration of elements present in the separated water phase.

Defoliation of vegetation can occur over an extensive area after a few days to a few weeks of contact with such drifting steam clouds. Early tests indicate that boron is responsible for such damage, although the possibility remains that other factors such as arsenic or H_2S oxidation products could also be involved.



Leaf samples collected at Tongonan from the vicinity of well 213 sixteen weeks after beginning a continuous discharge test have been analysed for arsenic and boron. Boron levels in leaves from a nearby control area and also in leaves which were known to have died before discharge commenced, ranged from 20-88 ppm. Boron in leaves killed by the discharge ranged from 104-520 ppm. Regenerating leaves collected after the end of discharge had intermediate boron levels.

The corresponding arsenic levels were more widely scattered: 0.7-5.1 ppm in the control area, 11-23 in the leaves which died before discharge, 4.3-50 in leaves killed by the discharge, and 7.8-8.5 in regenerating leaves.

Arsenic and boron levels in leaves of abaca damaged by the discharge of well Okoy 5 (Southern Negros) are recorded in Table 1. Arsenic levels were low in normal green leaves from the unaffected control area about 200 m from the well, but were roughly similar in dead leaves from the control area, surviving and dead leaves from the damaged area, and in young leaves regenerating close to the well. Boron levels, on the other hand, were 3-5 times greater in leaves from the damaged area than in leaves from the control area.

Table 1: Arsenic and Boron in Abaca Leaves

	Green Tissue As	Green Tissue B	Dead Tissue As	Dead Tissue B
Undamaged Control	1.8	36	10.4	49
Damaged by Discharge	10.7	149	14.3	287
Regenerating after discharge	8.1	111	-	-

Values given in ppm

Finally, some data are available for coffee leaves damaged by the discharge of well Mambucal 2 (Northern Negros). Boron levels in these dead leaves ranged from 250-268 ppm and arsenic levels from 0.2-0.5 ppm. Nearby sugar crops are also reported to have been adversely affected by discharge of this well.

Foliar spray of the toxic agent(s) appears to be the main cause of defoliation, not accumulation in the soil. Entry of toxic elements into the leaf is probably facilitated where stomata are jammed open by particles of silica accumulating on the leaf surface. (The latter is not particularly harmful in itself and at geothermal fields such as Mak-Ban (Makiling Banahaw) thick white deposits have been seen on banana leaves having little or no dead tissue). Evidence against the action of toxic factors through the soil rather than the leaves comes from the rapid growth of new leaves within a few days of the end of discharge, and also from the normal growth of camote (sweet potato) seedlings which, at the end of well discharge, were planted into a field of camote which had been killed by discharge of Mambucal 2.

DISCHARGE TO THE RIVERS VIA WASTEPONDS

The concentration of dissolved solids in Tongonan geothermal fluids at 2.5 percent is among the highest of any of the world's wet steam fields being developed for power production. The need for monitoring the chemical and biological effects of any such fluid released to the rivers is thus self evident. Although other Philippine geothermal fields developed to date have less concentrated waters, the intensive use made of local resources requires close monitoring of waterway conditions. Examples of resources which could be affected by geothermal well discharges include fishponds and fish traps in rivers flowing from the Southern and Northern Negros fields, kangkong *(Ipomoea reptans)* food crops grown in the Okoy River (Southern Negros), freshwater line-fishing and netting in the Ambuklao Reservoir (Daklan project), or the sea fishery of Ormoc Bay (Tongonan) and in almost every case the irrigation of rice or other vegetable crops.

Damage to the river ecology as a result of developing the Tongonan field appears to be restricted to the effects of excessive sedimentation from civil earthworks together with occasional oil sludge spills from drilling waste ponds, which in some cases are inadequately small because of the extremely confined spaces available in the steep terrain.

Chemical concentrations acceptable in Tongonan rivers during the development phase include an arsenic level of 1 ppm where the Bao River leaves the project area and a boron level of 5 ppm at the rice irrigation diversion. The most recent results available indicate that these limits are being met on most sampling occasions.

Drilling muds, fluids and additives as used in the Leyte and Negros geothermal fields have few adverse environmental effects, except in one instance where a fish kill in the Okoy River is attributed to use of a chemical gel rich in chromium (VI).

AMELIORATION METHODS

To minimise the adverse effects on rivers and hindrance to well test programmes, it is necessary to determine the maximum number of wells which can be discharged concurrently without exceeding the accepted chemical limits in the rivers. This requires information on the following:

- anticipated well chemistries
- anticipated wastewater flow rates from wells
- river resources and uses in regard to such factors as:
  - flora and fauna
  - crops
  - fish, fishponds
  - agriculture, irrigation
  - domestic water supply
- critical elements and their concentrations in regard to the various resources and uses
- river flow rates
- location along the river system where environmental limits have to be met

Damage to vegetation caused by droplets of geothermal water contained in drifting steam clouds can be reduced by appropriate silencer design or by use of diffusers in water-filled sumps, although such measures are unlikely to be completely effective in the case of long discharges or concentrated fluids. The attendant defoliation does not inevitably result in death of the larger trees and shrubs, which appear to be able to recover over a period of several years.