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ALTERNATIVES TO REINJECTION IN WAIRAKEI

H Peter Rothbaum

Chemistry Division, DSIR

ABSTRACT

The high cost of re-injection of geothermal discharge waters is largely due to their silica deposition potential. One should ask if reinjection of Wairakei discharge waters is really necessary to solve any environmental problems due to arsenic, boron, lithium, mercury or waste heat.

Alternative strategies are:

1. Doing nothing, and continuing discharging the geothermal waters from Wairakei into the Waikato River.
2. Chemical treatment to remove arsenic together with prevention of silica scaling and removal of waste heat. A successful pilot plant will be described which achieves these aims by a method particularly suitable to Wairakei waters. Alas-boron and lithium remain.
3. A more controversial suggestion involves chemical treatment of Wairakei waters as in No. 2, which might then allow direct discharge from a second geothermal station into the Waikato River without exceeding the WHO (World Health Authority) arsenic limit for drinking water.

The economics and our present state of knowledge of the environmental consequences of these options will be discussed. It is believed that present or projected levels of boron and lithium in the Waikato are unlikely to cause any harmful effects; however, more work is required to allow the public to be convinced of this.

Nearly all of the mercury evolved is in the geothermal steam, and therefore neither treatment nor reinjection of discharge waters will have any effect on the mercury level of the Waikato River.

In other geothermal stations (e.g. Ohaaki and Mokai) partial removal of silica, by a method being tested on pilot plants by Industrial Processing Division and Chemistry Division, would allow reinjection to be carried out at lower temperatures.

INTRODUCTION

The Wairakei geothermal station annually discharges about 50,000,000 tonnes of discharge waters into the Waikato. As a result the river water normally (but not always) contains below 0.05 g/t arsenic, which is the recommended World Health Authority (WHO) limit for potable water (International Standard for Drinking Water, 1971). Aggett and Aspell (1980) confirmed that 75% of the arsenic is derived from the Wairakei geothermal power scheme, and they calculate that the waters from the Ohaaki scheme would raise the arsenic content of the river water by 40%.

This water presently also contains about 0.3 g/t boron and 0.15 g/t lithium, both derived from the Wairakei scheme. The WHO has no standards for drinking water for either element, and in the WHO guidelines both are listed as elements for which "no action is required".

Other environmental effects from geothermal discharges are raising the temperature of the Waikato river by about 0.5°C, and discharging some mercury from geothermal condensates. The mercury concentrations in the Waikato River are generally below 0.02 mg/t, well below the 1 mg/t limit for mercury in potable water, recommended by WHO. Nevertheless, mercury accumulating in the sediments appears to result in unacceptably high mercury concentrations in some fish in the Waikato River. (Weissberg and Rohde, 1978).

It is sometimes claimed (Itoi et al., 1984) that reinjection will remove most environmental problems as well as recharging the geothermal field. However, some authorities believe that reinjection cools a geothermal field in the short term. In addition reinjection of discharge water will obviously not remove mercury derived from condensate. Overseas experience has shown that the main problems of reinjection are associated with the silica deposition potential of the waters. This is usually dealt with by reinjecting at a higher temperature, although in Hatchobaru in Japan reinjection takes place below 100°C and is only maintained by frequently drilling new injection wells. The large cost of this has prompted investigations into silica deposition in a porous medium showing an initial large decrease in permeability (Itoi et al. 1984).

Every geothermal field has its own chemical and environmental problems, and we suggest that in every case cheaper alternatives to reinjection should be carefully considered; reinjection should only be used where it is shown to be environmentally necessary. In the present paper some alternatives are considered for the Wairakei field; it is also pointed out that in other higher temperature fields, with higher silica levels, partial removal of silica would allow reinjection at lower temperatures.

ARSENIC REMOVAL AND SILICA STABILISATION

Shannon et al. (1982) described a pilot plant in which hot Wairakei discharge water flowing at 6 t/h was continuously dosed with ferric sulphate, a flocculant and a surfactant. The resulting iron floc with co-precipitated arsenic could be separated by dissolved air flotation in a total operating time of six minutes.

This treatment method is particularly suited to Wairakei waters, which has a relatively low silica content (about 550 g/t) and is not highly buffered. In Ohaaki waters, with higher silica contents (up to 900 g/t), the silica would polymerise too quickly; in addition the higher buffering capacity would require more acid, and the high sulphide content would precipitate as iron sulphide. Mokai waters have very high silica contents (up to 1200 g/t) but low buffering capacity and sulphide content.

Figure 1 shows the general layout of the pilot plant, which operated for several weeks.

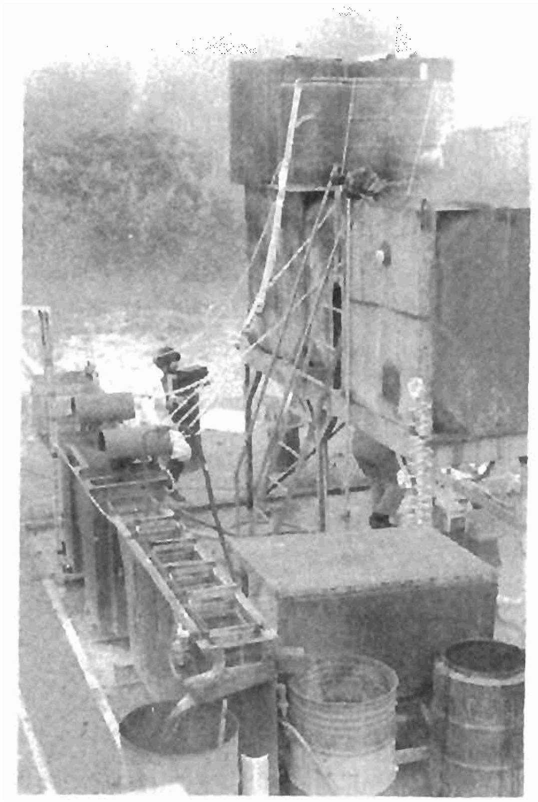

FIGURE 1. Wairakei arsenic removal pilot plant (Shannon et al., 1982) in operation.

Right back: Storage tanks for geothermal discharge water and reagents.

Left centre: Tanks for dosing, stirring and flocculating.

Left front: Dissolved air flotation tanks and scrapers for removing iron floc from the surface of the purified water.

Run	Fe added g/t	pH	Dried Solid Recovered g/h	Dried Solid Fe %	Dried Solid As %	Removed (withpolishing filter) Fe %	Removed (withpolishing filter) As %
55	11	7.0	27	18	3	100	51
57	11	5.1	109	26	8	96	71
59	10	4.1	137	22	11	84	93
60	10	3.7	107	21	13	69	91
61	17	5.0	168	33	8	99	87
62	17	4.7	203	31	8	99	93
63	17	4.1	231	28	8	92	97
64	17	3.8	211	26	9	78	98

steel was low provided a thin adherent continuous layer of silica was allowed to form. It can be concluded that conditions like runs 61 or 62 in the pilot plant of Shannon et al. (1982) will give essentially complete iron recovery, 90% arsenic recovery, very low silica scaling and few corrosion problems. If all Wairakei discharge water were treated by this process, the heat could be dissipated in a cooling tower, or even recovered usefully in heat exchangers. After discharge to the Waikato river there would be no heating and the arsenic content of river water would be about 0.005 g/t, which is only 10% of the WHO limit for drinking water.

Owers and Shannon (1982) estimated that this process would cost about 10c/tonne of water with a possible credit for the use of hot water. By comparison cost estimates for reinjection in 1982 ranged from 12c-15c/tonne of water; added to this will be 2c/tonne for loss of hydrogeneration of existing stations on the Waikato river amounting to 0.5 kWh/tonne of water.

The conclusion is that in 1982 the cost of arsenic removal was slightly less than the cost of reinjection. On the other hand reinjection also disposes of boron and lithium.

BORON AND LITHIUM

Present or projected levels of boron in the Waikato (0.3 g/t downstream of Wairakei) are unlikely to cause any harmful effects; however, the public may need to be convinced of this. Some wcrk on the effect on kiwi fruit of boron in irrigation water is presently being done by Ministry of Agriculture and Fisheries and Chemistry Division has proposed an extension of this project to quantify this effect.

There is veri little information on which to judge the acceptability of lithium concentration in natural, irrigation or drinking waters. There are no known problems associated with the present levels in the Waikato (0.15 g/t), which is about the same as in seawater (0.17 g/t), but considerably higher than in most fresh waters.

Some work has been done on chemical removal of boron on ion exchange resins; this is likely to be prohibitively expensive. However some recent calculations show that chemical removal of lithium may actually be economic. Further work on chemical removal processes for both elements is planned.

PARTIAL REMOVAL OF SILICA

If the silica concentration of geothermal discharge waters could be lowered to the solubility of silica, reinjection would become much simpler and could be carried out at lower temperatures. Owers (personal communication) at Industrial Processing Division has tested a method of flocculating silica, in a continuous pilot plant in both Wairakei and Ohaaki, and results look very promising. It appears the process is particularly suitable for Mokai waters, with high silica contents, and it is suggested it should be tried there.

Axtmann and Grant Taylor (1985) have successfully run a pilot plant in Ohaaki in which oversaturated silica is deposited on sand in a fluidised bed. This method also appears to be suitable for Mokai waters.

ALTERNATIVE STRATEGIES TO REINJEC'PION

Three options will be considered:

1. Doinq nothing. Wairakei waters would continue to be discharged into the Waikato. This would involve no additional cost at all, but would continue with present arsenic levels; downstream of Wairakei this is normally below 0.05 g/t, the WHO limit for drinking water. However, on occasions of low flow, this limit is sometimes exceeded. It is worth noting that water treatment by the alum-floc method (widely used

for cities on the Waikato) would in any case remove most of the arsenic present. Boron and lithium would remain at their present level. It is accepted that careful public justification of such a policy of continuation of discharge would be required.

2. Removal of arsenic with prevention of silica scaling The treatment method of Shannon et al. (1982) would result in a very low arsenic level and no heating of the Waikato river. Boron and lithium would remain at their present levei which are probably harmless, but would require public justification. The cost of this option would be slightly less than that of reinjection.

3. Removal of arsenic from Wairakei waters and direct discharge of Ohaaki or Mokai waters into the Waikato river The treatment method of Shannon et al. (1982) for arsenic removal is more suited to Wairakei waters than those of Ohaaki or Mokai. Treatment of the former and direct discharge of one of the latter would still leave the Waikato river well below the WHO limit for drinking water in arsenic. Boron and lithium levels might double their present level and there would be some heating (maybe 0.5°C) of the river downstream from Wairakei.

   We believe this option would still not be environmentally hazaraous, but would need strict justification. It would probably create considerable controversy. However there would be considerable economic benefits in not having to reinject at a second station, and having available additional low pressure steam. Furthermore every tonne of discharged water could generate 0.5 kWh in the existing hydrostations on the river.

RECOMMENDATIONS

1. It is suggested that before a final decision is made on whether to treat or reinject the discharge waters from the Wairakei geothermal station (and any future stations) the environmental effects of boron and lithium should be critically evaluated.

2. It is suggested that the Industrial Processing Division methoc of flocculating silica should be tried on a continuous pilot plant for Mokai discharge waters.

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