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Problem constituents in Australian groundwater drinking-water supplies[1]

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Groundwater is a common source of drinking supply in Australia's arid zone. The constituents in groundwater can limit its use either for drinking or for other domestic purposes. This paper discusses those constituents. It also highlights popular misconceptions about water-quality problems associated with groundwater, and encourages radical rethinking to ensure that people in the arid zone can use available water supplies appropriately to maintain a healthy lifestyle.

Introduction

About 80 per cent of all the water reticulated to towns and cities in Australia is of surface-water origin. However the majority of small communities, many of them in drier regions of Australia, are entirely dependent on groundwater. Much of this water is of ancient origin, a relic of past climatic regimes.

The quality of groundwater is related to both the geochemistry and residence time of water underground. The major water-quality problems experienced by small communities reliant on groundwater are reviewed. Options for small-community water supplies were considered by a workshop of the Australian Water Resources Council (1989), and further elaborated in the UNESCO Regional Seminar on 'Technology for Community Development in Australia, South-East Asia and the Pacific', presented in Alice Springs between 9 and 11 July 1990.

Groundwater quality

Undesirable constituents in groundwater can be broadly classified as:

- those of health concern, which are normally present at levels below those that can be detected by sight, smell, or taste; and
- those that have an aesthetic and economic effect, typically present at high levels.

Pesticides, petroleum products, heavy metals, and other introduced chemicals can pollute groundwaters. However, in lightly populated areas, the main constituents of groundwater are those that occur naturally or which have always been associated with human settlement. Health-related parameters include microorganisms (bacteria and viruses), nitrate, and fluoride. Aesthetic and economic parameters include total dissolved solids (TDS — water salinity and water hardness), colour (iron and manganese), and acidity (pH and total alkalinity). The maximum normally accepted levels (National Health and Medical Research Council–Australian Water Resources Council, 1987, guideline levels, in parentheses) are:

- total dissolved solids — 1500 (1000) mg L^{-1}
- hardness (as $CaCO_3$) — 600 (500) mg L^{-1}
- turbidity — 25 (5) NTU[3]
- colour — 50 (15) TCU[4]
- iron[5] — 1 (0.3) mg L^{-1}
- manganese[5] — 0.5 (0.1) mg L^{-1}
- acidity — pH 6.5–8.5
- taste/odour — not offensive

For many domestic issues, such as showering, much higher levels need to be accepted in practice.

Health-related constituents

Microorganisms. The major health concerns associated with nearly all water supplies relate to the levels of pathogenic bacteria, viruses, and possibly protozoans present. Well protected deep aquifers are sometimes the safest to use, and are normally free of harmful microorganisms. Conversely, shallow aquifers are often polluted, especially where they are connected to surface waters or where shallow wells, septic tanks, and other systems directly contaminate the groundwater.

Two categories of microorganisms are recognised:

- those of animal, bird, or human faecal origin; and
- those of environmental, normally soil, origin.

Microorganisms of environmental origin are best known for the problems they cause in swimming pools. Current wisdom doubts that environmental microorganisms are a major health hazard in drinking water. Faecal pathogens in drinking water, on the other hand, are probably contributing factors to both morbidity and mortality (sickness and death) in small poor communities. Communities that lack an adequate water supply — those with poor hygiene — can, however, improve their living standards by washing clothes and bathing in untreated water.

Just which microorganisms most compromise untreated supplies is a matter for conjecture. Bacteria — including *Salmonella, Campylobacter*, and *Shigella* — and enteroviruses are probably important in many situations. The protozoans *Giardia* and *Cryptosporidium* are of uncertain importance in Australian supplies of drinking water, partly because they are extremely difficult to isolate from water and partly because epidemiological evidence of their having an effect is lacking.

Since most groundwaters contain little suspended organic material, they are usually relatively easy to disinfect. Boiling water or, at a community level, treating water with chlorine at around 3 mg L^{-1} will usually render water safe to consume.

Nitrate. The health effects of elevated nitrate levels in groundwater have been recently reviewed by the National Health and Medical Research Council (1990). Despite widespread fears about the presence of nitrate in drinking water, there appears to be no clinical evidence that it has adverse health effects in Australian arid-zone communities. The only individuals likely to be affected are babies under three months of age. It is now accepted that the baby must also be suffering other complications. In practice this amounts to poor nutrition and hygiene. There is firm evidence that poor hygiene is associated with inadequate water supplies.

The National Health and Medical Research Council has encouraged review of the policies of water authorities reticulating

[1] Poster paper presented at conference on 'Arid zone water: a finite resource', Alice Springs, 11–14 April 1991 (*Issues in Water Management* number 6 of the Centre for Continuing Education, Australian National University, Canberra, ACT).

[2] Aquatech Pty Ltd, 52 Jaeger Circuit, Bruce, ACT 2617.

[3] Nephelometric turbidity units.

[4] True colour units.

[5] Both sluggish flow and biological activity in water mains can result in the levels of iron and manganese at the tap being much higher than those that enter the reticulation.

high-nitrate water supplies. Further, most water uses — including drinking-water supplies for all individuals, except young babies — are not compromised by nitrate. Water always should be made available, whatever the nitrate level, and supplementary or treated water provided for drinking purposes where nitrate levels are excessive (Table 1).

Fluoride. Fluoride levels are occasionally elevated in groundwater. This phenomenon appears to be confined to particular districts or regions. Low dietary levels of fluoride are beneficial (National Health and Medical Research Council, 1990) in the prevention of dental caries (tooth decay), whereas highly elevated levels, generally well above 2 mg L^{-1}, can have an adverse effect on bone strength. Elevated levels are unlikely to be a cause of significant health problems in Australia. The United States Environment Protection Agency (1991) confirms the 1987 maximum contaminant level for fluoride as 4 mg L^{-1}.

The treatment of naturally high-fluoride water supplies is expensive. Alternative options include mixing the water with water containing little or no fluoride, or simply providing a low-fluoride water source for drinking and cooking. Uses of water other than for drinking and cooking, such as bathing and washing clothes, are not compromised by high-fluoride levels in the water.

Constituents of aesthetic and economic importance

Total dissolved solids (salinity and hardness). Total dissolved solids (TDS) are what remains when all the water is removed from filtered water by, for example, evaporation. Suspended material — that is, undissolved material such as plant and algal debris — may also be present in water, but is generally only a problem in surface waters.

Salinity. In practice, dissolved solids comprise mainly sodium, calcium, and magnesium salts. Sodium salts give water a brackish or saline taste. High levels of sodium make water unpalatable. Some communities use supplies with up to 5000 mg L^{-1} TDS (mainly sodium salts). Levels above 1000–1500 mg L^{-1} TDS (mainly sodium salts) are, however, considered to be of very poor quality for drinking (Table 2). Such water is still suitable for a wide range of uses such as bathing, and washing clothes and dishes. Taste thresholds for different sodium salts (the minimum level that many people can detect) are listed in Table 3.

Saline waters can be quite aggressive, particularly if chloride levels are high, promoting corrosion of water fittings and mains. They can also be unsuitable for garden watering.

Hardness. Hard waters (those containing calcium and magnesium salts) cause a range of problems. They adversely affect taste, scale hot-water systems and fittings, and increase laundry soap and detergent requirements.

The proportions of calcium and magnesium can vary widely depending on the hydrogeology of the groundwater system. Limestone produces high-calcium waters, whereas dolomite produces water with roughly equal levels of calcium and magnesium. The economic importance of hard waters is well recognised: for many uses very hard waters need to be treated or the effects, such as blocked pipes and poor heat transfer in heating systems, must be accepted.

Fortunately, waters which are temporarily hard are not difficult to treat, and systems such as brine-softening and lime-softening are feasible on a small-to-medium scale. These waters contain calcium and magnesium bicarbonate. Waters containing other calcium and magnesium salts are termed permanently hard, and are expensive to fully treat. A ranking of water hardness levels is provided in Table 4.

Table 1. Guideline values for nitrate in water supplies.

Use pattern	*Guideline level (mg L^{-1} as N)*
Babies under three months	10
Community drinking-water supply	23
General use	no limit

Table 2. Drinking-water-quality rating for total dissolved solids (World Health Organization, 1982).

TDS (mg L^{-1})[1]	*Aesthetic quality*
Less than 300	excellent
300–600	good
600–1000	fair
1000–1500	poor
Greater than 1500	unacceptable

[1] Current Australian guideline level is 1000 mg L^{-1} (National Health and Medical Research Council–Australian Water Resources Council, 1987).

Table 3. Taste threshold at normal temperatures for various sodium salts.

Salt	*Sodium level (mg L^{-1})*
Sodium carbonate	20
Sodium chloride	150
Sodium nitrate	190
Sodium sulphate	220
Sodium bicarbonate	420

Table 4. Water hardness rating (World Health Organization, 1982).

Classification	*Hardness as $CaCO_3$ (mg L^{-1})*
Soft	0-60
Medium hard	60–20
Hard	120–180
Very hard	Greater than 180

Iron and manganese. Iron and manganese are troublesome trace metals, and are a common cause of water discolouration. Iron stains washing and plumbing fixtures reddish brown, whereas manganese typically stains black. These metals can affect taste, and bacteria can concentrate them in sluggish-flow areas of water-supply mains; for example, they are a common problem in cul-de-sacs. Mains-supply design or water treatment can reduce their nuisance value.

Iron and manganese are widespread in nature, and almost any groundwater or bottom water in a storage reservoir is affected by their presence. On contact with air, these metals often form a scum. Even when they remain dissolved or in colloidal suspension, they can adversely affect the appearance and taste of water. Levels of iron around 0.3 mg L^{-1} and manganese around 0.1 mg L^{-1} are marginally acceptable at the tap, though problems may occur if these are the levels entering a water-supply system. Iron and manganese are essential elements, and at the natural levels found in water are of no health concern.

Acidity. Some soft, as opposed to hard, groundwater contains high levels of dissolved carbon dioxide, and is therefore acidic. Communities in some coastal areas of the Northern Territory,

for example, have highly acidic supplies with a pH commonly below 5. Such water is highly aggressive, particularly to cement and galvanised iron. Either pH correction or use of acid resistant materials such as plastics is essential for maintaining the integrity of such systems.

References

Australian Water Resources Council, 1989 — Guidelines for low cost water supplies in small communities. *Australian Government Publishing Service, Canberra.*

National Health and Medical Research Council, 1990 — 110th Session — draft report of the Water Quality Committee on Nitrate. *NH&MRC,Canberra.*

National Health and Medical Research Council–Australian Water Resources Council, 1987 — Guidelines for Australian drinking water quality. *Australian Government Publishing Service, Canberra.*

United States Environment Protection Agency, 1991 — National primary drinking water standards. *National Sanitation Foundation Standard* 60, appendix E (January 1991).

World Health Organization, 1982 — Drinking water guidelines. *WHO, Geneva, draft report* (unpublished).