

A tidier way to clean up water

The underground water supplying a growing proportion of Perth's needs is typically dirty, smelly, and foul-tasting. But when it emerges from the treatment plant it is indistinguishable from the clean water drawn from the river reservoirs in the hills.

Treatment removes a variety of substances — including clay, dissolved organic compounds, iron, and the hydrogen sulfide that is mainly responsible for the water's bad smell. It also takes out bacteria, viruses, and algae.

The plant that treats most of the Perth underground water employs a process that has remained unchanged in its essentials for 80 years or more. This tried and proved technique cleans up town water around the world. But alongside the conventional plant is another, processing 35 million litres of water a day, that employs an entirely new process called Sirofloc.

Devised at the CSIRO Division of Chemical Technology in Melbourne, Sirofloc's advantages include substantial savings in the cost of treatment plants and big reductions in waste-disposal problems. Work on the process began only in 1976, and progress from the laboratory bench to full-scale production occurred at near-record pace. Development to full commercial scale has been carried out by CSIRO and AUSTEP, a joint venture of Davy McKee Pacific and J. O. Clough and Son.

Last year the Tasmanian Rivers and Water Supply Commission placed the first order for a Sirofloc plant won in open competition against all competing systems. The \$1.2 million plant is due to begin treating the water supplied to Bell Bay, north of Launceston, by next summer.

Perth's Sirofloc plant — financed by the Federal Department of Science and Technology under a scheme to encourage



The Perth plant.

the development and marketing of water-treatment technology in Australia — has an experimental role as well as its very practical one in the water-supply system. Scientists and engineers are using it to look for ways to further improve the workings of the process and its economics.

The water fed through this plant is as difficult to treat as virtually any used for a town supply, which makes it ideal for use in an experimental plant. A system that can cope with such unpleasant water should be able to cope almost anywhere else.

The water has a turbidity rating of about 20, compared with the requirement for drinking water of less than 1. Turbidity is caused by material such as clay that is suspended, rather than dissolved, in the water, and its readings are derived from measurements of light-scattering by the suspended particles.

Measurements of light absorption give water's colour rating, and the figure for the Perth underground water is between 30 and 100, compared with the usual requirement of less than 5. 'Colour' is dissolved material — mostly organic compounds derived from rotting vegetation. If you fill a bath with water that has a colour rating of 10, you can see the colour. If the rating is 50, you won't see the bottom of the bath. Clearly the Perth water, in its untreated state, would not be nice to bathe in.

The hydrogen sulfide (rotten egg gas) in it, at a concentration of between 1 and 2 milligrams per litre, would make the bath even more unpleasant. Dissolved iron is another contaminant that would make

itself felt, leaving a stain on the bath and, perhaps, the bather.

The conventional way

In the traditional water-treatment method, fine particles of aluminium hydroxide, generated from alum, gather up the material causing turbidity and colour, and the other impurities. The particles carry a small positive electrical charge, and as a result attract the generally negatively charged contaminants. With contaminants attached, they come together (or flocculate) into loose aggregations (flocs) that gradually settle to the bottom of the treatment tank. The cleaned water is then removed and run through sand filters that prevent any remaining flocs from entering the water-reticulation pipelines.

The gelatinous watery sludge left behind, containing the alum flocculant and contaminants, has to be disposed of.

Commonly it is spread out on the ground in large 'drying beds', where evaporation and infiltration into the earth eventually get rid of most of the water. The semi-solid residue is then usually transported to landfill sites.

Because of the large areas required for drying and the cost of transport, disposal of the sludge can be very expensive. In some parts of the world, where the land needed for drying is not available or the weather rules out evaporation as the drying method, centrifuges are used to remove the sludge water. This adds greatly to the disposal costs.

Waste disposal is much less of a problem with Sirofloc, because the material that picks up the impurities during water

treatment is recycled rather than dumped. The quantity of waste is much smaller, and essentially all it comprises, apart from water, is the collected impurities.

It could be used for irrigation, or simply be allowed to infiltrate back into the ground. Where the water being treated was taken from a river and represented only a small proportion of its flow, the waste could be returned to the river — what was being dumped, after all, would be essentially what was removed, minus most of the water.

The magnetite method

Instead of aluminium hydroxide, Sirofloc uses magnetite particles to gather up the water's impurities. Activated by treatment with caustic soda, they acquire a positive charge when dispersed in the water requiring treatment. Usually small quantities of acid need to be added to the water, as lowering the pH increases the charge on the magnetite, and hence increases its attraction for the negatively charged contaminants.

Settling out the particles plus impurities is a much quicker operation with Sirofloc than in the conventional system, because advantage is taken of the particles' magnetic properties. The magnetite-water mixture is passed between the poles of a magnet. As a result, the particles become magnetic, clump together, and rapidly fall to the bottom of the settling tank.

Because this happens in minutes compared with the hour or two it takes the flocs to settle in the conventional process, a much smaller area of settling tank is

needed in a Sirofloc plant, resulting in significant cost savings.

Also the settling out is virtually complete, eliminating the need for the sand filters used in conventional plants and again reducing costs. However, the next step in the process — regeneration of the magnetite for re-use — does not have a counterpart in the conventional process and reduces the cost savings of Sirofloc.

The magnetite with attached impurities is washed with caustic soda, raising its pH and in the process changing the charge on its surface from positive to negative. As the magnetite and contaminants now carry the same charge, they repel each other. Next the magnetite is washed with untreated water and magnetically separated from the impurities washed off. It is then demagnetized, which breaks up the clumps, preparing the particles for re-use.

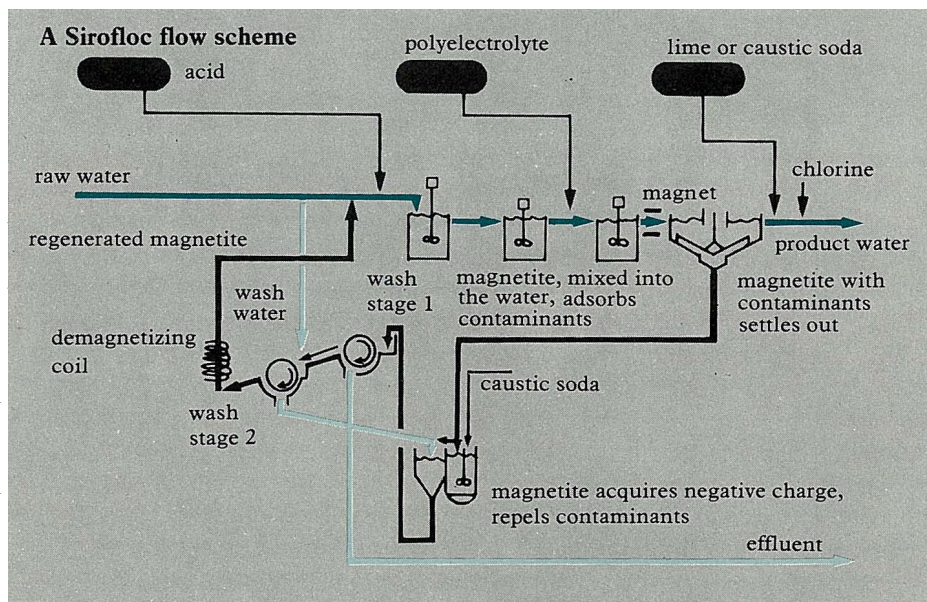
About 50 tonnes of magnetite are cycling through the Perth plant. Most of it came from a nearby plant that up-grades mineral sands mined in Western Australia; magnetite is a by-product of the up-grading process. Inevitably some is lost as water treatment proceeds, but the CSIRO and AUSTEP team expects losses to amount to less than a tonne a year, which is not very much from a plant processing 35 million litres of water per day.

Polymers help

The basic Sirofloc process deals most effectively with high levels of colour. The water it will have to cope with in Tasmania should suit it well; this has a colour rating of about 140 — high enough to conceal the bottom of a partly filled bath — but is not very turbid.

To reduce turbidity to acceptable levels in some water, including Perth's, small quantities (about 1 milligram per litre) of organic polymers known as polyelectrolytes are used in conjunction with the magnetite. Interaction of the magnetite and polymer promotes turbidity removal. The polyelectrolytes either end up in the Sirofloc plant's waste stream or remain with the recycled magnetite. Higher turbidity can mean that higher concentrations of magnetite and polyelectrolyte are needed, together with bigger and more precise adjustments to the incoming water's pH.

Water hardness creates difficulties, too, as it does with the conventional alum-treatment process. The problem, in Sirofloc's case, is that the calcium and magnesium ions that cause the hardness affect the electrical charge on the magnetite.



This enhances the adsorption of the impurities, but off-loading the contaminants can become more difficult.

Nevertheless, tests done on a wide range of waters show that, with suitable adjustments to the processing conditions, Sirofloc can cope in most situations. Even water drawn from the Murray River, with turbidity readings between 130 and 250 and a colour level of 250, has been upgraded to drinking-water standard, with help from an appropriate polyelectrolyte.

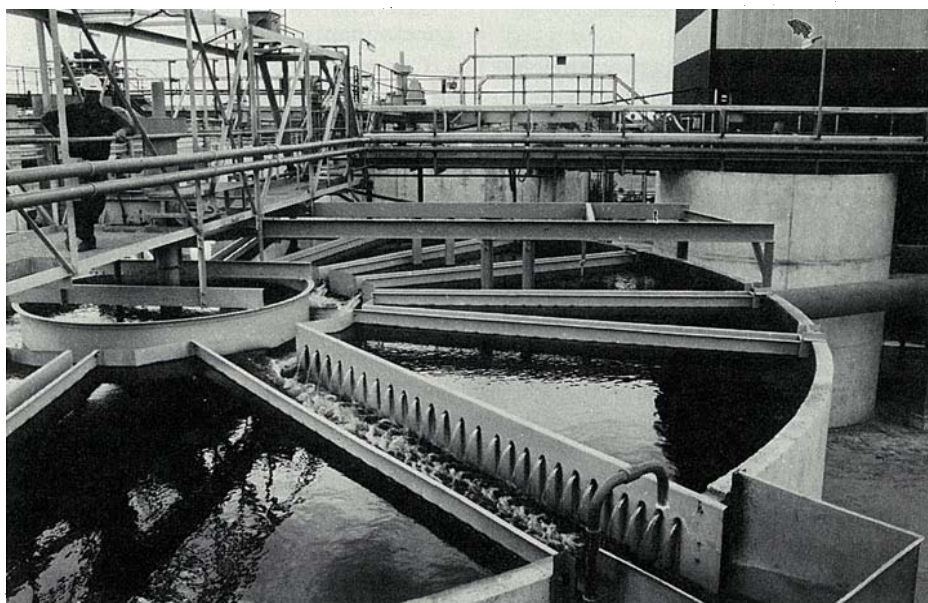
The CSIRO team has tested both Sirofloc and alum treatment on water from dozens of sources. Usually both methods proved equally effective, and in several cases Sirofloc did significantly better.

Cost savings

Studies of comparative costs suggest that, despite the need for equipment to regenerate the magnetite, the capital cost of a Sirofloc-based water-treatment plant



These magnetic drum separators in the Perth plant help prepare the magnetite for re-use.



Treated water flows out of the Perth Sirofloc plant.

In the mid 1970s, spurred by estimates that Australian cities and towns would need new water-treatment plants worth more than \$500 million by 1990, the CSIRO Division of Chemical Technology began looking at the prospects for improving treatment technology. The researchers decided to examine approaches making use of magnetism to speed the settling-out process and allowing re-use of the flocculant.

In early experiments, they found that use of magnetized ion exchange resins as the flocculant gave good results, but the resins were too expensive to be competitive. So they looked at magnetite, a readily available natural compound with the wanted magnetic properties.

The problem with it was the apparent necessity to coat it with a substance that would acquire the positive charge needed to gather up the water's turbidity and colour. Dr Don Weiss, then Chief of the Division, suggested coating the magnetite with ferric hydroxide. This worked well initially, but the coating proved too fragile.

Success came when Mr Luis Kolarik found that magnetite particles acquired the necessary electrical characteristics if they were simply washed with dilute caustic soda and used in conjunction with alum. The next major step was the discovery by Mr Neville Anderson that small doses of cationic polyelectrolyte, used instead of alum, made magnetite much more

effective at gathering up suspended material.

The early Sirofloc experiments were 'jar tests', in which the interaction of magnetite with different types of water and the effects of changes in acidity and alkalinity were studied in simple laboratory glassware.

Producing a workable process posed a new set of problems. The most difficult of these turned out to be separating the contaminants from the magnetite particles and preparing the magnetite for re-use without using uneconomically large quantities of wash water and caustic soda.

Dr Tony Priestley of the Division came up with a viable answer: magnetic drum separators, used for years in the coal-washing industry. In a counter-current washing train, these reduced the amount of wash water required to 3-6% of the plant's total water throughput. Since then, further development has brought this figure down to 1%, increasing the efficiency of the Sirofloc process and reducing the amount of effluent produced.

Because by 1977 Sirofloc was showing such promise, CSIRO placed a contract with the Australian Mineral Development Laboratories in Adelaide to build and test a pilot plant in Adelaide. This started operating in December 1977, treating 140 000 litres of water a day. The following year, after discussions with the Perth Water Board, which was impressed by the results of laboratory tests in Mel-

bourne and Perth, the pilot plant was moved to Perth. There it demonstrated Sirofloc's ability to deal with the city's bore water.

In late 1979, the Department of Science and Technology awarded AUSTEP the contract to build the demonstration plant in Perth that treats 35 million litres per day. Since then, AUSTEP has worked on engineering improvements aimed at increasing Sirofloc's efficiency, and has won the contract to build the new treatment plant in Tasmania.

The CSIRO team, co-ordinated by Mr Bill Raper, is also continuing to look at ways to make Sirofloc more efficient — Dr Priestley dealing with chemical engineering aspects, Mr Anderson with ways to improve the basic process, Dr David Dixon and Mr Kolarik with the magnetite's surface chemistry, and Dr Brian Bolto with the behaviour of polyelectrolytes and ways to design better ones.

Dr John Atherton and Dr Ian MacRae, of the University of Queensland's Department of Microbiology, are studying Sirofloc's ability to remove bacteria and viruses from water. This work, initially commissioned by the Division, has shown that Sirofloc matches the 99% and above removal rates normally achieved by the conventional treatment process. However, neither form of treatment eliminates the need for chlorination of domestic water supplies, because neither gives 100% removal.

could be as much as 30% less than that of an equivalent conventional plant. Running costs should be much the same for the two systems.

The main sources of savings are the very large reduction in the size of the tank required for settling out the flocs, avoidance of the need for sand filters, and elimination of the need for large areas of land for sludge drying. Inevitably, the characteristics of the water to be treated influence the cost of each type of plant and also the cost comparison.

To see whether Sirofloc may find a role in water-pollution control as well as the treatment of town water supplies, the scientists have tried it out on a range of industrial effluents. They have found that it can clean up many effluents sufficiently to allow their re-use in industry. Among

the substances that it will remove in large quantities are heavy metals, synthetic dyes, oil, algae, viruses, and bacteria. It can improve the quality of effluent from sewage-treatment plants.

Economic considerations will ultimately determine whether Sirofloc finds applications in effluent treatment; the question to be determined in each case is whether it does the job as effectively as alternatives and more economically. Results to date indicate that one job it may do competitively is clean up the 'white water' effluent produced by paper-making plants.

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More about the topic

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