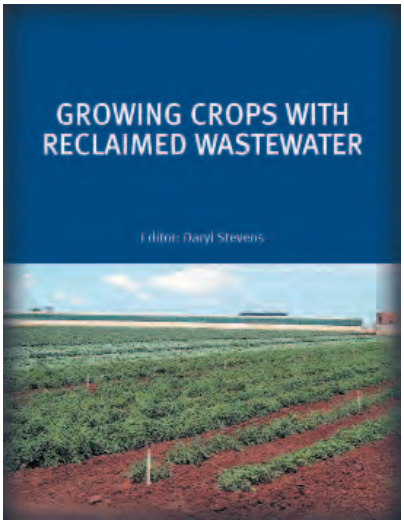

Growing Crops with Reclaimed Wastewater

Daryl Stevens (Editor)

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Reclaimed water use in Victoria

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The vast majority of Victoria's population resides in the greater Melbourne area and, thus, most wastewater is managed by Melbourne Water through the Western Treatment Plant at Werribee and the South Eastern Purification Plant at Carrum. However, many smaller cities and towns also increasingly face the need to reduce discharge into the marine environment (principally bay and ocean outfall) and freshwater environments through land application or other forms of reuse.

Historical perspective

The Melbourne and Metropolitan Board of Works (MMBW) commenced operation in 1891, and by 1897 the Main Outfall Sewer from Melbourne directed sewerage to the Board's farm at Werribee for treatment prior to the treated effluent being discharged into Port Phillip Bay.

Part of this treatment process included land filtration and grass filtration through overland flow. Since 1900, cattle and sheep have grazed the effluent-treated pastures. After paddocks have drained fully following irrigation, livestock are introduced until the next irrigation is due. A presentation in 1978 on the utilisation of wastewater at Werribee discussed the 'effective and economic use of wastewater by land filtration, grass filtration (overland flow) and lagooning' (Croxford 1978). This report also described research underway to determine the practicability and economics of using treated effluent for irrigation of high value agricultural and horticultural crops including cereal and oilseed, forage crops and various vegetable rotations.

In 1975, the South Eastern Purification Plant was commissioned at Carrum to service the eastern and southern parts of greater Melbourne leaving the Werribee Farm to service the other needs of Melbourne. At the South Eastern Purification Plant the wastewater is treated by an activated sludge process and the secondary treated effluent is principally discharged into Bass Strait at Boag's Rocks near Cape Schank. Some diversion of the secondary treated effluent has been directed onto areas of recreational turf (eg golf courses, parks and gardens) and some market gardens. Restrictions on market gardening use ensured that the reclaimed water (Class C) did not come into direct contact with produce that may be consumed raw (see *Chapter 2*).

Changing environmental and health standards and guidelines

The commencement of the South Eastern Purification Plant at Carrum was a key driver in developing new ideas for wastewater reuse and for creating a framework for environmental and health standards for the use of reclaimed water through legislation and guidelines. Prior to this, a joint committee of the MMBW and the State Rivers and Water Supply Committee (SRWSC) tabled an interim report relating to the organised reuse of wastewater (Bird and Lang 1968). This led to some field experiments on agricultural reuse but work was placed on hold since they depended on the availability of wastewater from the South Eastern Purification Plant.

Following the 1972–73 summer drought, the government appointed a Standing Committee on Water Supply for Victoria with a subcommittee on reclaimed wastewater use. The inclusion of a Commission of Public Health medical officer was an important development because until then, the emphasis was on water reuse in terms of engineering, but now public health was on the agenda. In 1973, a mission to investigate practices in other countries relating to the reuse of wastewater lead to

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a seminal report with 16 recommendations. The recommendations included the creation of necessary legislation to authorise and control the use of wastewater and establishment of a body responsible for administering applications and managing compliance (Lang *et al* 1977). Up to this stage, there were no regulatory frameworks or guidelines for the use of wastewater in Victoria.

Through the recommendation of the Health Commission, the State Government legislated the use of wastewater in the *Health (Amended) Act* 1977 and Regulations made thereunder, the Health (Use of Waste Water) Regulations 1978. These regulations contained microbiological standards adopted from the Australian Water Resources Council and the National Health and Medical Research Council. The 1978 Regulations were amended in 1985 to qualify the use of reclaimed water in pastures for grazing cattle because of the threat of transmission of beef measles and beef tapeworm. Reclaimed wastewater had to be ponded for 60 days or treated by sand filtration before it could be used on pastures. Other amendments included the introduction of the restriction that spray irrigated crops including vegetables must be cooked, peeled or treated in a manner to destroy any human pathogens.

Preceding this, research undertaken at the Vegetable Research Station at Frankston (see *Frankston Vegetable Research Station*) included the investigation of health and safety aspects of the reclaimed water relating to bacteria, viruses and heavy metals (Kaddous *et al* 1986; Smith *et al* 1972). The positive results led to the first official use of reclaimed water for horticultural crops from the South Eastern Purification Plant in 1981. The use of wastewater was regulated through the issuing of licences permitting the use of wastewater under the Health (Use of Waste Water) Regulations 1981. The permits were for the growing of vegetables that were required to be cooked prior to eating, peeled before being eaten uncooked or processed commercially by a method that would destroy pathogenic organisms. The permit stipulated only wastewater that conformed to a specification was to be used. This specification covered three parameters: faecal coliforms less than 1000 per 1000 mL, biological oxygen demand with a median level of 15 mg/L and suspended solids with a median level of 20 mg/L.

The regulation also specified the use of notices easily legible to farm workers and the public stating the water used was not safe for drinking and the user had to provide a sampling point for the water so Health Commission officers could take samples. Pond location and requirements were also described with emphasis on water runoff and access by stock and the public. Conditions for spray application were clearly stated. Other conditions included the issue of protective clothing to employees and the non-interfacing of wastewater connections with any other water supply system on the property. The permit was conditional on limiting the use of the water to the intended purpose and the condition that the Health Commission could at any time change the conditions of use or revoke the permit.

More recently, the Environment Protection Authority (EPA) released guidelines for the disposal of wastewater to land by irrigation (EPA 1983). The revised EPA 1991 guidelines (EPA 1991) incorporated the Health Commission conditions of use and described the site selection process, wastewater quality in relation to soils, plant growth and public health and management in relation to land use and the environment but they did not apply to the irrigation of crops for human consumption. A less prescriptive EPA guideline was released in 1996 (EPA 1996) that incorporated most of the previous guidelines in an easy-to-understand format with information on potential reuse options, roles and responsibilities, wastewater quality, wastewater treatment, site and system control, performance monitoring and reporting and notification. It also included the use of wastewater in food crop production. It rated water quality into three classes that delineated suitability for use on food crops.

Future of reclaimed water use in Victoria

In 2001, an updated set of guidelines was released for the use of reclaimed water (EPA 2001b) and for disinfection of treated wastewater (EPA 2001a). These new guidelines generally adopted approaches described in the recently released national guidelines for sewage systems (ARMCANZ 2000), but have some variations to reflect Victorian conditions (eg increased restrictions on some horticultural products).

Despite these guidelines, adoption of reclaimed water irrigation in Victoria has been slow, mainly because most of the water available (Class B and C) has restricted usage to a few applications. The trend with Water Authorities has been to establish an internal policy on the reuse of reclaimed water that is often guided by the commercial reality of supplying treated water or by the cost of treating the water.

The Victorian Government has set a target of 20% of effluent to be recycled from the Eastern and Western

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Treatment Plants in the greater Melbourne region by 2010 (Metropolitan Water Recycling Committee 2001). In order to address the 20% recycling target, a preliminary 'desk top' study has been undertaken to identify Prime Development Zones suitable for sustainable irrigated agriculture and horticulture. Prime Development Zones must have soils suitable for high value agriculture and horticulture with access to a secure supply of quality reclaimed water ensuring sustainably low environmental impact. The concept of recycling wastewater has been reinforced with the release in June 2004 of the Victorian Government White Paper (DSE 2004). This document sets out policy for the use of alternative water supplies for non-drinking uses and policy related to a reduction of ocean discharges of effluent.

Research into reclaimed water use in Victoria

Frankston Vegetable Research Station

The potential for using reclaimed secondary treated effluent for the production of vegetables has long been recognised in other countries (Day *et al* 1979). Not only was wastewater accepted as a substitute for higher quality irrigation water, the nutrients present in the reclaimed water, principally nitrogen, potassium and phosphorus, were seen as a partial substitute for manufactured fertiliser leading to reduced fertiliser costs even though the potential contamination of groundwater and drainage water with nitrogen and phosphorus (in sandy soils) had environmental implications. However, accumulation of trace amounts of heavy metals in the soil and the retention of bacteria and viruses on vegetables irrigated with wastewater was of concern since it could lead to food chain contamination (Hinesley 1972).

This lead to a research study from 1977 to 1983 at the Frankston Vegetable Research Station on a loamy sand using secondary treated wastewater from the South Eastern Purification Plant at Carrum (Kaddous *et al* 1986). Using equivalent rates and frequencies of reclaimed water to that of bore water previously used by local growers, the total and marketable yields of successive crops of lettuce (first), carrot, cabbage, celery, spinach, lettuce (second) and tomatoes were recorded. Plant uptake and recovery of nitrogen, phosphorus, potassium, cadmium, chromium, copper, iron, nickel, zinc and their accumulation in the soil were also recorded. After balancing the manufactured fertilisers to compensate for the nitrogen, phosphorus and potassium supplied by reclaimed water, a 7% to 18% increase in the marketable yield was measured relative to the use of bore water. Kaddous *et al* (1986) concluded that the increased yields were due to the regular supply of trace amounts of other water soluble nutrients in the reclaimed water that were absorbed through the foliage as well as the plant roots. This contrasts to normal practice where large amounts of manufactured fertilisers are applied to the soil prior to sowing, and a later side dressing, leading to higher leaching losses of nitrogen and potassium.

Kaddous *et al* (1986) calculated that the use of reclaimed water represented approximately a 35% saving in fertiliser costs because reclaimed water saved about 60%, 33% and 40% of inorganic nitrogen, phosphorus and potassium fertiliser, respectively. The boron content in wastewater was sufficient to eliminate the common occurrence of boron deficiency in celery on these sandy soils without having any adverse effects on boron sensitive crops. A further saving from using reclaimed water was the bore water saved; between 0.64 ML and 5.6 ML of bore water depending on the crop and seasonal weather conditions.

No accumulation of heavy metals was recorded for the edible parts of the vegetable crops or the soil receiving wastewater irrigations. Furthermore, total coliforms, *Escherichia coli* and *Salmonella* levels on vegetables that were spray irrigated with wastewater did not differ significantly from vegetables purchased from commercial outlets around Melbourne. The presence and survival of human enteric viruses were studied and the results suggested no health effects from the consumption of the crops were likely. Although viral contamination was seen as a potential problem for crops eaten within two weeks of harvest, no work on parasites was conducted as part of that study (Smith *et al* 1972).

Black Rock Sewerage Treatment Plant, Bellarine Peninsula

During 1999–2000, cooperative trials were undertaken by scientists of the Department of Natural Resources and Environment in conjunction with Barwon Region Water Authority and local growers on the Bellarine Peninsula of Victoria (Harapas and Premier 2000; Premier *et al* 2000).

The first trials were commissioned to establish the growth characteristics of potatoes irrigated with reclaimed water, and to determine the suitability for human consumption, including their suitability for the fresh food market based on their heavy metal and microbiological contaminants.

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This research indicated that the yield and size of potatoes produced using reclaimed water were comparable with those obtained with traditional water sources in the area. Disease proneness, postharvest storage life and cooking behaviour were not adversely affected by the use of reclaimed water. Although potatoes are known cadmium accumulators, there were no concentrations of cadmium that exceeded the maximum permissible level for those grown using reclaimed water (ie they were suitable for human consumption). This was expected as the cadmium level in the reclaimed water was significantly lower than the Australian and New Zealand Environment and Conservation Council (ANZECC) maximum recommended limit (ARMCANZ 2000). Potatoes grown using treated wastewater did not have a different microbiological profile than those grown with normal irrigation water even though the high nutrient status of the reclaimed water could encourage the growth of plant pathogens affecting the crop (Premier *et al* 2000).

In 2000, another study was undertaken using reclaimed water (215 faecal coliforms/100 mL) from the Black Rock WWTP for the production of hydroponic tomatoes. Results showed the lack of salmonella, listeria and faecal coliforms and extremely low levels of *E. coli*, indicating insignificant microbiological health risks from eating tomatoes grown with this reclaimed water. Heavy metals concentrations in tomatoes were insignificant from a human health perspective (Harapas and Premier 2000).

Buckland Valley

In 2001, a study was also undertaken for North East Water to examine the feasibility of using reclaimed water in the Buckland Valley. Treated wastewater from the township of Bright was found to have the potential to benefit apple, grape and chestnut growers with only minor modification to current irrigation practices.

Commercial adoption of horticultural production using reclaimed water

Despite the early use of reclaimed water by the MMBW, usage figures have been difficult to obtain until comparatively recent years. Melbourne Water data from the financial years 1995/96 to 2000/01 are shown in Table 1.4.

For the Western Treatment Plant, about 10% of the total volume of effluent discharged into Port Phillip Bay is used for irrigated pasture production. Other water authorities throughout Victoria (eg Barwon Water) also supply reclaimed water to industries for production of vegetables, ornamental flowers, tree lots and grapes (for more detail see Radcliffe 2004).

Summary

In Victoria, treated wastewater has been used in agricultural production systems for more than 100 years at the MMBW farm at Werribee. In more recent times, secondary treated wastewater from authorities such as the South Eastern Purification Plant at Carrum, and Barwon Water at Black Rock Sewage Treatment Plant, has been successfully demonstrated to be safe for use in some vegetable production.

However, even though low risk uses of secondary treated effluent have been identified and access to these wastewaters is assured, the rate of acceptance of this option by industry has not been great relative to the volume of wastewater available. Now there are clear and safe guidelines for the various classes of reclaimed water (wastewater), there is scope for a vast increase in the use of reclaimed water for agricultural and horticultural production. With the increasing price of high quality irrigation waters and progressive water shortages to meet the increasing demands for agricultural and horticultural production, it is anticipated that reclaimed water will be seen as an increasingly viable option for profitable and environmentally sustainable production.

Table 1.4 Historical wastewater discharge and recycling volumes from Melbourne Water.

	2000/01	1999/00	1998/99	1997/98	1996/97	1995/96
Total volume recycled (ML)	4423	1656	1564	1279	1400	0
Total volume discharged (ML)	322 865	295 559	295 304	302 777	304 250	164 250
Total percentage recycled (%)	1.4	0.6	0.5	0.4	0.5	0.0

Source: Melbourne Water.

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