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Feasibility Study for a Dry Composting Toilet and Urine Separation Demonstration Project

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EXECUTIVE SUMMARY

Dry composting toilets (DCTs) including urine separation in conjunction with grey water discharge to sewer can be an economical and practical sanitation option in an urban area, particularly where sewerage systems are not available or are under capacity. A high proportion of household waste loads (including over 80% of the phosphorus and nitrogen) can be beneficial recycled to farmland, and water can be saved, all without increasing energy consumption for sanitation. Market research indicates demand for such a technology. A demonstration project involving equipping 12 new apartments with DCTs and an agricultural compost and urine recycling trial is proposed.

INTRODUCTION

DCTs with urine separation (Figure 1) offer a sanitation option that recovers nutrients and minimises water use and pollutant discharges to the environment. This system provides a practical tool to make cities more ecologically sustainable.

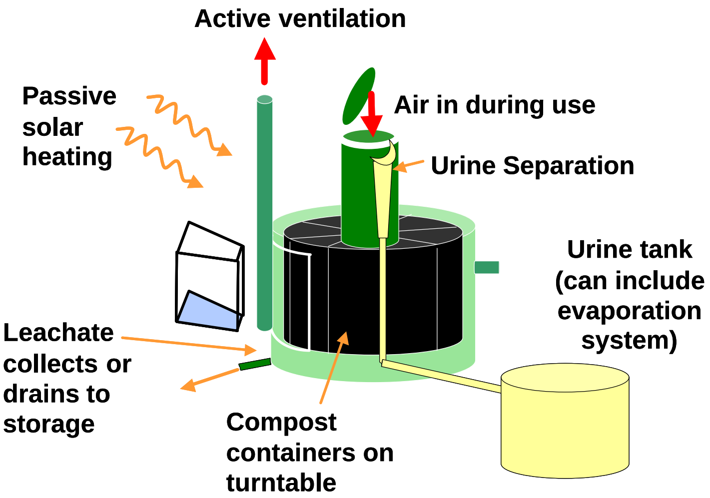

Figure 1 Proposed composting toilet – rotary type

This paper presents the results of the feasibility study phase of a project aimed at demonstrating and independently assessing the benefits of DCT technology application in urban areas. Funding for the study was provided jointly by the Victorian Smart Water Fund and by the project team. The investigations reported were carried out between July and November 2003 and build on earlier work by the principal author (Crockett, 2000).

Benefits

DCTs have become the technology of choice for permanent public toilet facilities in national parks and for many isolated roadside rest areas and houses. However, the technology has wider application and is already being adopted more broadly in other countries. The advantages of DCTs over conventional water-flush toilets include:

- a 15% to 25% saving in household indoor water use

- over 80% reduction in nutrient loads to sewer
- a 25% reduction in BOD to sewer
- a 50% reduction in salt load to sewer.

They are compatible with other water saving technologies such as grey water recycling, waterless urinals and rainwater capture. DCTs have the potential to extend the life of existing capacity in sewerage systems and reduce overall lifecycle and economic cost of new centralised systems, which essentially become grey water-only sewers. In addition DCTs, especially with urine separation, can provide a safe-to-handle, nutrient rich replacement for manufactured agricultural fertilizer.

Perceptions and challenges

Use of DCTs has been limited by: perceived operating problems (odour, difficult operation, health risk), residue disposal opportunities and restrictions, significant additional cost to the household compared to installation of a standard toilet, difficulty of retrofitting in existing buildings, cultural acceptability and institutional discouragement. This paper demonstrates that these issues can be overcome and that the technology is appropriate, marketable, environmentally beneficial, can reduce greenhouse emissions and is economically feasible.

The demonstration project

The next phase of the project, involving installation of DCTs in 12 new, premium-quality medium to high-density urban apartments, is aimed at demonstration in an urban application and further information gathering. The feasibility study concludes that application in an unsewered town or in unsewered areas could be economically and environmentally superior to conventional sewerage. The demonstration project will be used to test this conclusion.

COMPOSTING TOILET TECHNOLOGY

The process

DCTs rely on aerobic biological breakdown of solids in human faeces and toilet paper and, for some systems, added fibrous organic matter including vegetable scraps, wood shavings and sawdust. Bacteria and other organisms are responsible for this breakdown and earthworms are sometimes added to aid composting in cooler climates. The process can inactivate pathogenic bacteria, protozoa and virus and reduce numbers of infectious ova. The final product is a humus-like material, about one third of the mass of the raw waste, that can be beneficially recycled. Recent development has shown that separation of urine within the toilet bowl is beneficial to compost toilet operation and can recover up to 60% of urine in a relatively sterile state for direct use as fertilizer on farmland.

Current guidelines prevent use of compost on consumable crops and require burial of material 100 mm below ground. This may be too conservative, and the agricultural recycling trial proposed as part of the demonstration project is aimed at assessing risks associated with recycling on dry land grain an oil seed crops. There are no guidelines for use of separated urine.

Gases generated from composting include carbon dioxide, limited amounts of oxides of nitrogen, hydrogen sulfide, ammonia and amines. Other odour-causing gasses may also be released. The proposed demonstration project will investigate composition of the gases and the need for and effectiveness of a biofilter for odour removal. The air handling system must minimise energy use and must be separate from apartment ventilation.

It is desirable that the temperature in the compost chamber, and therefore the compost matter, is kept at or above 20 °**C** to enhance the rate of composting. During cooler periods this may require supplementary heating using a combination of passive and active solar heating, recovery of heat from building ventilation air and grey water and possibly fuel or electricity.

The composting unit and key operational aspects

A rotary DCT is proposed for the demonstration project because it eliminates the need to handle un-composted material. Figure 1 shows the general arrangement of this type of unit. The proposal is to use the Australian Rota-Loo® of which there are several thousand operating. The key element is the carousel on which compost bins are located and rotated. Within the front of the pedestal is a compartment for separately collecting most of the urine which is piped to a urine storage tank. The toilet lid is kept closed when not in use and a fan creates a downdraft through the pedestal during use. This prevents odour emission into the indoor room, a distinct advantage over a conventional water-flush toilet. The fan also maintains air flow through the composting compartment at all times via a separate inlet vent which maintains the compost in an aerobic condition. Odour emission and ammonia loss from the urine tank is limited by storage in a closed container with only a small vent to discharge displaced air.

Faecal matter and toilet paper collect in one of several perforated compost containers on a turntable within the compost chamber. Mixing of the compost and addition of worms or fibrous matter is not necessary with this design. Insect breeding and escape is controlled by a combination of ventilation and insect screening.

Around 60% of urine is separated at source and collected in the urine tank. Any liquid not collected in the urine-separating compartment in the front of the bowl drains through the compost and is either evaporated or collected separately as leachate. Handling collected urine (which has received the equivalent of ultra filtration in the human body and is hence usually sterile) requires clean and controlled conditions but some contamination with faecal matter and blood is inevitable. It has been found in extensive trials in Stockholm (Johansson, 2000) that pathogens are inactivated during storage at the high pH of the urine provided temperature is maintained around 20 °**C**. This is a desirable aspect with respect to safety of handling. Collected urine is a liquid high in nitrogen, phosphorus, potassium and salt and direct application of urine as fertiliser to grain crops has been successfully trialled in Stockholm. Health risk from use of urine has been assessed quantitatively and found to be negligible (Hoglund et al, 2002).

Separation of urine eliminates one of the major problems with non-separating DCTs; over-saturation of the compost with liquid. Saturation limits aeration and leads to anaerobic conditions, odour, unfavourable carbon to nitrogen ratios and slowed microbial growth.

The DCT is cleaned by periodic wiping/brushing of the bowl with a cloth or brush dipped in weak vinegar solution. This requires changed behaviour, however unlike a conventional toilet bowl, which is relatively narrow and tapers in to the bottom, the base of a compost toilet bowl is wider and therefore has less contact with waste. The surface of the bowl also has a very smooth finish to aid in cleaning. Cleaning is easier than with a conventional toilet bowl because of the absence of a U bend.

Maintenance & waste removal

When a compost container on the turntable becomes close to full, the turntable is rotated to bring an empty compost container under the chute from the bowl. Rotation may be necessary once every one to three months depending on usage. For the demonstration project this will be undertaken by the contractor responsible for collection.

A full compost container remains on the compost chamber turntable for one revolution, taking about one year (or a half revolution over six months if two toilets share one compost unit).

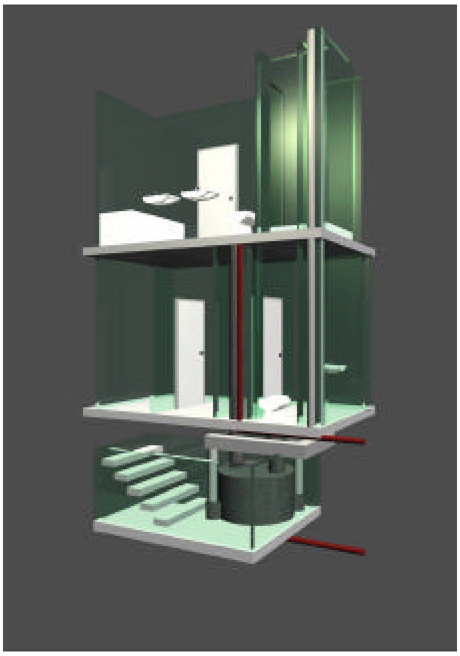

Figure 2 Proposed installation

By this time the mass has reduced to a third and the solids have become stable and relatively dry. In the proposed trial, each apartment will have two toilet pedestals, one on the ground floor and one on the first floor of the apartment unit, both attached to one composting unit. The waste chutes will be opposite each other and feed into separate bin compartments.

The urine-separating pipework needs care, and blockage with scale and hair can occur if the urine piping is not properly designed or maintained.

PROPOSED DEMONSTRATION PROJECT

Proposed apartment layout

Figure 2 shows the proposed arrangement for the demonstration in a two storey, high-density urban development in inner Melbourne. Cost of the building structure is increased compared to a standard conventional structure. This is due to the requirement for access to the compost chambers below floor level and because of the size of ducting between pedestals and composters. This cost can be reduced if the site has a slope or if the structure is single storey. Overall the installation will increase the apartment cost by some $3 500 compared to conventional sanitation but some of this cost may be offset by savings in sewerage costs and headworks charges.

There is a risk that apartments with DCTs may not be easily sold or resold so plumbing will be arranged to allow for future replacement of the compost unit and installation of either urine-separating water-flush toilets with continued urine collection or conventional toilets.

Key engineering, environmental & architectural issues

The key wastewater engineering, financial, economic, environmental and social issues addressed in the feasibility study included: water saving potential, odour, ammonia and other gaseous emissions; risk to health of occupants and to maintenance, transport, and agricultural workers who apply residues to land; capital and operating cost (including comparison of options for full-scale scenarios); energy use compared to conventional sewerage; maintenance issues; reliability of operation; value of the products for replacement of synthetic fertilisers; practicalities and requirements for a high density application; and market demand and acceptance. The feasibility study also identifies gaps in information that should be addressed in the demonstration project.

Key architectural and building issues investigated included: building heating and ventilation; maximising passive solar heating and natural ventilation; access for maintenance and aesthetics. These issues were investigated by means of preliminary design development, literature review, discussion with other users and researchers, field inspections and preliminary design calculations.

Transport of residues

A DCT system does not connect to sewer and in a dense urban area it is unlikely to be sustainable to recycle the residues on site. Therefore, this urban application of DTCs requires a road-based transport system for removal of the compost, urine and leachate to a location where it can be beneficially recycled.

Urine, whilst it could be evaporated on site (with significant energy and maintenance input) will make up the major part of the mass load to be transported (64%) and the leachate will account for some 30%. For the 12 apartments proposed for the demonstration project an estimated 12 tonne of urine, leachate and compost will need to be removed per year made up of 0.7 tonne of compost and around 11.3 tonne of urine and leachate. This equates to around 0.44 tonne/person.year. Removal trucks will require suitable access to the DCTs at the apartment site for regular biannual or quarterly visits to the site. Trucks will have to be appropriately designed or modified transport vehicles. They will have to use appropriate collection routes that minimise fuel use and provide easy access to the recycling site or sites. In addition, standby collection arrangements and standby recycling or disposal sites will be required in order to provide a similar or better level of reliability to a conventional sewerage system.

Resource recovery - the agricultural use trial

Demonstration of the practicality and safety of transport and agricultural recycling of the residues is a key element in the proposed demonstration project. The proposal is to set up a 2 ha agricultural recycling trial site including necessary monitoring facilities and agricultural equipment for application of the residues to dryland grain and possibly oil seed crops and associated control crops.

Monitoring of the demonstration project

The proposed demonstration project will be a research and development project, therefore extensive monitoring facilities will be installed at the apartments including water and grey water flow metering and automated recording, off-gas monitoring and energy metering. The trial will involve monitoring of residue and crop quality, soil and crop response and microbiological and chemical quality. The monitoring program is planned to run for at least 12 months at the apartments and 2 years at the agricultural recycling site. It will also include log sheets which occupiers will be encouraged to keep (on a voluntary basis with appropriate incentives). The project will provide valuable and independent data on a wide range of important factors related to water use and grey water, urine and compost generation, energy use and data that is not currently available on air emissions from DCTs.

Demonstration project cost

The demonstration project is estimated to cost around $0.73M. $0.23M of this will be for equipment and additional building costs associated with the research and development aspects of the project at the apartments and $0.3M will be for the agricultural recycling trial. The demonstration phase of the project is subject to funding being obtained. The developer is keen to proceed.

RESULTS OF THE FEASIBILITY STUDY

Experience elsewhere

Internationally there have been several trials of elements of the proposed technology in Scandinavia, which have been closely monitored, including urine separating toilets with conventional sewer disposal of faecal matter. In Canada, DCTs were installed in a multi-level office building at the University of British Columbia. Conclusions of a post-occupancy survey of users of the building were reviewed and these were encouraging.

There has been considerable work done on use of DCTs in Australia (Maher & Lustig 2002, Mitchell et al 2002) but it has not been reported to the level of detail of this feasibility study. CSIRO's Urban Water Program has reached similar conclusions to those of this feasibility study (Mitchell et al, 2002).

There are many small and private single installations and public toilet installations of DCTs around Australia. The design and performance of some of these installations has been reviewed and observations from site inspections were favourable.

At an inner-urban environmental park in Brunswick, Melbourne (CERES), several manufactured and site-constructed DCTs have been used for about four years. Urine separation at CERES was being tried with good success in that it appeared to aid composting. The composters were not heated and appeared to work well. Worms have been added to some of the composters and appear to assist the process and not be affected by the environment within the composter. There was no odour in the toilet rooms, which are used by the public. Leachate and urine are discharged to wetlands and compost is buried on site.

The Charles Sturt University campus at Thurgoona, near Albury, NSW, has around 300 staff and students (including some 40 residential students) and several years ago installed 47 pedestals connected to 25 Clivus Multrum composters. Urine from one waterless urinal and compost leachate is discharged to a wetland system and compost is buried on site. The toilet rooms are odour-free and bowls are easily kept in a very clean state. Midges are plentiful within the composters but not externally or in the toilet room. Flies have not been a problem. The composters and air vents are colonised by spiders because of the plentiful supply of midges. The spider webs require regular removal to maintain air flow. Both an older staff member and a young student commented that, since they have been using the DCTs, they find wasting and polluting clean water in a flush toilet repugnant. This is an interesting reaction and the reverse of expectations of many people not familiar with properly designed DCT systems. Odour problems have only occurred at this installation when fans have broken down or have been undersized. Some composters serve up to four pedestals spread over two floors. Maintenance staff at the campus were enthusiastic about the DCTs and did not find the tasks they undertook (and demonstrated) of raking the top of the compost pile, removal of compost and cleaning of the chutes and vents objectionable.

A private residential installation demonstrated a relatively poor composting rate, due to the location of the composter under the house without warmth from adequate solar exposure. Hence compost bins from the rotary unit are removed and placed in a warm shed. The owner found that midges were an initial problem but were easily controlled by stretching nylon stockings over the vents. The 4 W ventilation fan has been very reliable (7 year life) and is powered from the household solar panel system. Leachate from this system is discharged to a septic tank with household grey water, and compost is buried on site.

Regulations, guidelines and planning

A significant part of the feasibility study has involved investigation of regulations and guidelines related to sanitation in the state of Victoria, to assess if any particular impediments to the demonstration project exist. Regulations and guidelines are generally not yet specific to DCT systems and recycling of the residues. However some specific and a number of more general health and environmental guidelines will apply. Regulatory bodies are supportive of the demonstration project.

The Australian/New Zealand Standard (AS/NZ 1546.2:2000) for DCTs provides a base level for design and operation of the units themselves, and also suggests sampling and testing requirements to ensure that the residues from the system do not present a risk to human health. The Standard also requires that compost be buried under 100 mm of soil and that no food crops be grown using the compost. There is no guidance in Australian standards or regulations on use and disposal of urine.

The overall conclusion is that there is support in State Government Policy and in the policies of other regulatory and utility bodies that should encourage application of resource-conserving technologies such as DCTs and that no specific impediments exist.

Marketability of Apartments with Composting Toilets

In order to gauge the likely level of interest, understanding and acceptance of DCTs in a residential setting, a market survey was developed by GHD and Bensons with input from Environment Equipment. The survey results were collated and analysed with the assistance of GHD’s Community Consultation Group.

Survey questions were introduced in three stages - General Questions (to gauge level of interest in sustainability), Questions about DCT systems and Operational questions. All questions were designed to give respondents the chance to rate their opinion or feelings on an issue from ‘strongly agree’ to ‘strongly disagree’. Opportunity was also given to provide comments, some demographic details and optional contact details to provide or receive more information.

The survey was distributed in hard copy to approximately 3 000 former, current and prospective clients of Bensons Property Group, and also to the public via an information page for the project on the GHD website (www.ghd.com.au/compostloo).

The results indicated that there is genuine interest in DCTs as a viable, ecologically sustainable sanitation system with over 90% of respondents indicating a willingness to consider purchasing an apartment with DCTs and with a majority saying they would be willing to pay up to $5 000 more for an apartment incorporating resource-conserving features. Respondents to this survey had little background knowledge of the system. The survey was intended to establish the current level of information, not to educate potential users. Where respondents did have more background knowledge of DCTs, it appears that their views were more favourable toward DCTs.

Specific attention will need to be devoted to consumer education for awareness and benefits of DCT systems in order to develop a definite support base for development of the demonstration apartments and for future mainstream application of DCT technology. Indications are that there is support in the community for ecologically sustainable features in urban developments. It is likely that support for DCTs in particular would rise with increased consumer knowledge of the process.

Achievable water and waste load reduction

The load components of toilet (black water) and grey water which make up sewage are shown proportionately in Figure 3. The loads from urine have also been included. An important and interesting conclusion is that if all human body waste is diverted via a DCT system then indoor household water use can be reduced by up to 28% and wastewater pollutant loads discharged to sewer can be reduced by between 40% and nearly 90%. Large amounts of the phosphorus and nitrogen in household wastewater can be diverted directly to beneficial uses since faecal and urine waste together contribute around 88% of total nitrogen and 83% of total phosphorus loads. Furthermore, urine separation on its own can recover about 55% of household nitrogen load and 48% of household phosphorus load (assuming 60% capture of urine) in a form that can be readily transported and used as a fertiliser without processing. Figure 3 is based on a variety of mainly foreign sources and one aim of the demonstration project is to confirm this data for Australian conditions.

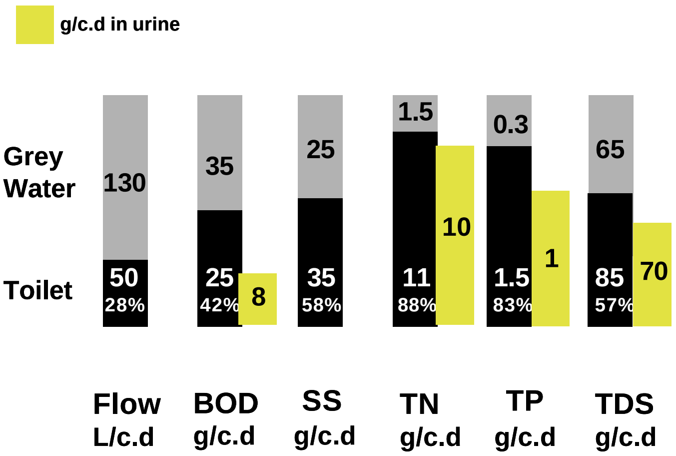

Figure 3 Load components from sewage & grey water

Lifecycle Energy Savings

Table 1 sets out estimates of the energy input and energy-related greenhouse gas (GHG) emissions to operate a DCT system compared to the energy input and GHG emission for handling excreta in a sewerage system.

The comparison shows that a DCT system with road transport has potential to be slightly lower in energy use than conventional sewerage. This benefit will increase where there is considerable pumping lift in the sewerage system and where the sewage treatment plant does not generate any of its own energy. However, the comparison also indicates that conventional sewerage is an energy-efficient transport system. If mains power and gas are used to ventilate and heat the compost toilet system it can have a greater energy usage than a sewerage system. The possible savings in embodied energy in fertiliser from recycling of compost and urine in terms of fertiliser substituted is included as an offset for DCTs. A similar offset could be claimed for sewage biosolids but, in most cases, nutrient recovery in biosolids is a small fraction (10 to 20%) of nutrients in the sewage.

Transport and recycling

The feasibility study reports on discussions with possible cartage contractors, the project architects and potential recycling site owners and includes costs for a contract collection system with standby provisions. It was determined that contractors are available and interested and would assist in setting up the transport equipment and system for the demonstration project.

A possible agricultural recycling site has been identified at the Melbourne Water Western Treatment Plant site and a preliminary design of the trial has been prepared and reviewed by agricultural specialists. The recycling trial is estimated to cost around $0.3M and will cover health, agricultural and environmental aspects associated with use of the residues.

Table 1 Estimated energy use per capita per year for collection, treatment and reuse of excreta

Energy-using operation	Conventional Sewerage (WC waste and flushing water)	DCTs
Ventilation and supplementary heating MJ/c.yr	0	0 - 358
Transport MJ/c.yr	105	202
Treatment and Recycling of Residues MJ/c.yr	142 – 434	39
Embodied energy in fertiliser saved MJ/c.yr(negative = saving)	Negligible	- 70
TOTAL MJ/c.yr	**248 - 540**	**171 - 529**
Equivalent diesel fuel use (L/c.yr)[1]	6 - 14	4 - 14
Approximate GHG Emissions CO_2-e kg/c.yr	19 – 42	13 - 41
Lifetime Emissions (50 years) tonnes CO_2-e kg/c.yr	**1.0 – 2.1**	**0.7 - 2.1**

Assumptions:

Sewerage system involves pumping against a 50 m head.

DCT uses 4 W for ventilation (this could be reduced with solar-powered fans)

An allowance has been included for supplemental heating of the compost chamber in winter.

Compost and urine collection by truck running a 100 km round trip at 50% of full load

Energy use is expressed as fuel burnt at the power station or in the transport vehicle

Wastewater sludge cartage by truck running a 50 km round trip

[1] 1 MJ is equivalent to the energy available from combustion of about 26 mL of diesel fuel

Sustainable handling of grey water

At low urban densities of up to 4-6 persons per ha, sustainable application to land of urine, leachate and compost within the urban area is possible because these residues can be stored during wet, low growth rate periods and because application rates would match plant demands. However, even at this low population density, grey water disposal or recycling remains an issue in wet periods when there will be runoff.

If grey water is handled on site in a low-density fringe area or small country town, then DCTs and on-site grey water treatment offer a lower cost approach to sanitation than sewerage. However, the impact of on-site grey water treatment in wet months is not considered to be as environmentally acceptable as centralised treatment, storage and dry season recycling of grey water.

In dense urban environments of more than 30 person/ha, a grey water sewerage system is essential and compost, urine and leachate generated from DCTs would have to be largely disposed of off-site on agricultural land to avoid groundwater or surface water pollution (through elevated nutrient concentrations).

Financial evaluation of composting toilets compared to conventional sewerage

Table 2 sets out the capital, annual operating and total annual costs per household for a base case, Option T2.1 of conventional sewerage of 2000 new urban medium to high-density houses. This is compared to Option T2.2 where both trunk sewer and central treatment plant upgrading is required to serve the development and the alternative approach, Option T3.2 of installing DCTs in all residential units and a sewerage system to take only grey water - considered a more environmentally beneficial approach to sanitation.

Table 2   Costs of sanitation options for a dense urban development of 2 000 residential units

Option	Capital Cost		Annual Operating Cost		Total Annual Cost	
	$M	$/household.yr	$M pa	$/household.yr	$M pa	$/household.yr
T2.1 Conventional sewerage	37.9	18 972	0.32	162	4.1	2 059
T2.2 Conventional sewerage, if new capacity is required	43.5	21 755	0.32	162	4.7	2 338
T2.3 DCTs/Grey Water Sewerage	41.1	20 528	0.51	253	4.6	2 306

Table 3 compares DCTs applied to a smaller settlement of 2000 persons on an urban fringe (say a backlog area) or remote from centralised sewerage (such as a small rural town). Option T3.1 is for conventional sewerage with a local treatment, storage and tree lot irrigation system. Option T3.2 is for conventional sewerage and pumping 15 km to a trunk sewer with adequate capacity. Option T3.3 assumes DCTs with urine separation, residue recycling on agricultural land and a modified sewerage system to treat grey water and recycle it for use on open space within the urban area. Option T3.4 assumes DCTs with urine separation, residue recycling on agricultural land, on-site grey water treatment in wetlands and transpiration beds but with ongoing discharge to stormwater in wet weather (a no-sewerage option).

Table 3 Options for sanitation of a fringe (backlog) area or isolated town

Option	Capital Cost		Annual Operating Cost		Annual Cost	
	$M	$/household	$M pa	$/household.yr	$M pa	$/household.yr
T3.1 Conventional Sewerage and Local Treatment and Irrigation	9.44	11 795	0.193	242	1.14	1 421
T3.2 Conventional Sewerage and Pump 15 km to Main Sewer	9.26	11 579	0.166	207	1.09	1 365
T3.3 DCTs & Grey-water Sewerage with Local Lagoon Treatment and Recycling	8.20	10 254	0.107	134	0.93	1 159
T3.4 DCTs & On-site Urine and Grey Water Disposal	5.91	7 391	0.046	58	0.64	797

In outlying backlog areas or in towns distant from sewerage where a major transfer main or local treatment plant would be required (Option T3.2 and T3.1), DCTs with grey water sewerage (Option T3.3) is likely to offer a significant cost advantage over a conventional sewerage scheme.

Annual operating costs for a DCT/grey water sewerage system would be around $100 less or 45% less than conventional sewerage for a backlog area or outlying town, but, from Table 2 perhaps $90 or 55% more per household than for conventional sewerage in a large urban subdivision because of longer transport distances.

The feasibility study also undertook economic evaluations of several scenarios including the impact of increasing water and energy price, the effect of having to remove phosphorus and nitrogen at a wastewater treatment plant and scenarios where the sewage treatment plants did and did not generate their own energy.

Comparisons of total cost were based on a simple calculation of annual cost rather than on present value analysis. This was because the latter would favour the least capital cost option and is not considered an appropriate decision-making tool in the current circumstances where the priority is to reduce water and resource use and where the cost of resources, energy and water is likely to rise in future more than the cost of labour, property and other non-resource based items.

Increasing water costs in future could make DCTs with grey water sewerage a cheaper option than conventional sewerage. Therefore, although the DCT/grey water sewerage option for a denser urban development is probably higher in capital cost than conventional sewerage, it may have a total annual cost advantage in future. This potential advantage is due to the water savings it makes possible and is assisted by the value of the fertiliser-replacement materials recovered.

The relative cost of energy does not have a significant impact on the relative cost advantages of conventional sewerage versus DCTs with grey water sewerage because energy costs are not a major factor in either system. Whilst DCTs with grey water sewerage can be more energy efficient than conventional sewerage, this requires extra expenditure on solar generation of electricity for ventilation fans. This may be an unfair penalty against the technology since a DCT system with fan has a significant benefit of no odour in the toilet room compared to conventional water-flush toilets without fans.

These outcomes are based on limited evaluation and need further confirmation based on more reliable capital and operating cost data. However, they do indicate economic justification for a demonstration project, particularly for an area where sewerage capacity is limited. Further refinement of the costing work will be part of the demonstration project.

CONCLUSION

The feasibility study concluded that a demonstration project for DCT technology in a high-density urban development is economically and environmentally justified and that there is growing market demand for such technology. The technology is proven and, for the householder, provides a sanitation solution having no odour and requiring no more maintenance than a conventional water-flushed toilet.

The study has also concluded that DTCs with urine separation offer a potentially economical alternative with distinct environmental advantages compared to conventional sewerage and to grey water recycling for toilet flushing. Loads to sewer are reduced and life of a sewerage system can be extended if DCTs are used on a significant scale. Any increase in water price in future will increase the cost advantage of DCT systems.

The technology does not avoid the need for grey water sewerage provision in dense urban developments by may do so in low-density areas where grey water can be sustainably applied to land. However, sustainable on-site grey water is probably not often achievable.

If funding is received, the project will provide extensive independent and reliable data on achievable water, nutrient and BOD load reduction. It will also provide a practical demonstration of user-acceptability. The agricultural trial of compost and urine recycling will provide useful data on health risks, agricultural benefits and potential savings in chemical fertiliser.

A copy of the feasibility study report executive summary is available for downloading from the GHD website (www.ghd.com.au/compostloo).

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