URINE SEPARATION: TRIALS IN QUEENSLAND AND VICTORIA

The Editor

Introduction

Separate collection of urine from specially designed toilets has been in operation in Europe for some years and offers advantages both for sustainability and for decentralised sewage systems.

A trial in SE Queensland commenced in 2008 at a private residence in the Currumbin Eco Village.

In western Victoria, a trial at a high school of waterless toilets incorporates urine separation.

The two papers which follow this introduction (Hood, Gardner, Beal and Crockett, Daniels) summarise their results to date.

Public acceptance of the concept is a vital component of the trials, as well as the value of the agricultural use of the stored urine as a nitrogen, phosphorus and potassium fertiliser.

Nutrient Balance

Concepts of long-term global sustainability are focussed on energy, water and food. For the latter, apart from soil and water availability, an adequate supply of nutrients is essential. Fossilised nitrogen fertilisers were exhausted a century ago and large scale agriculture relies on fixation of atmospheric nitrogen, a process which demands huge amounts of energy, currently mainly from fossilised fuel. The supply of the other two essential elements, phosphorus and potassium, relies on mining fossil deposits. These sources are approaching economically viable limits.

Mass balance studies in Europe suggest that the average adult excretes about 1.5-3.8 kg N, 0.4 kg P and 1kg K each year which is equivalent to the same mass of nutrients in 200 kg wheat. All of this could possibly be recycled if the compost from waterless toilets was usable for local agriculture, and of course this has long been normal practice in peasant economies, with inherent health dangers. The question is whether the practice can be replicated in a 'civilised' community without such risks, and in a manner acceptable to a residential community and local agriculture. (The agricultural use of biosolids from large-scale sewage treatment plants only partially fulfils this function).

Another approach is to collect the bulk of the urine from a specially designed low-flush toilet, store it until it is sterile, then use it as an agricultural fertiliser. This approach is based on the fact that of the total amount excreted in faeces and urine, the urine accounts for, very approximately, 80-% of the total excretion of nitrogen, 50% of phosphorus and 70% of the potassium (Larsen and Gujer 1996; Maurer *et al*.,2003).

Urine separation and reuse has long been common in small scale farming, but only recently has it been considered as a component of larger scale agriculture. Several experiments have been conducted in Europe where up to 130,000 urine separating toilets are currently in use (Johanssen *et al*. 2000, van Betuw, 2007, Wilsenach *et al*. 2002).

Another possible benefit of urine separation is the saving of energy in a treatment plant. Considerable energy is expended in removing nitrogen, and phosphorus in particular, in treatment processes and often requires the inputs of extra chemicals such as methanol or molasses to balance the C/N for the microbial biota. Thus the separation of urine may be particularly suitable for decentralised developments.

Water Economy

In a water-short community, or where discharge of sewage effluent to the environment is problematical, waterless, or composting, toilets have long been used. They were first developed in Scandinavia, for use on the rocky islets commonly used for holiday homes where the 'long-drop' used by rural communities was not feasible, and discharge to the sea proscribed. Numbers of commercial designs have been available for over 30 years, and within Australia are used both in rural residences and in National Parks. Whether, in such situations, the 'compost' is actually used beneficially may be doubtful.

Continued trials would be valuable.

One difficulty with such designs is that the volume of urine has to be reduced by evaporation, otherwise the compost becomes saturated and anaerobic. In cooler climates this usually necessitates an electrical heating system. Full or at least partial separation of urine helps to solve this problem.

With regard to water-flushed urine separating toilets, trials in Europe (Johansson et al, 2002) have shown that since it only requires 0.1-0.3 L of water to flush the urine (about 10% of the usual low-flush) and design of the bowl enables a 2-6 L flush for the solids, there is a significant saving in flush water.

Conclusion

Despite the challenges, it is worth continued trials of such systems to assess their suitability for Australian conditions and the following papers make a start.

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(Extracted from Hood, *et al*, Benalla Conference paper)

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DOMESTIC URINE SEPARATION CAPTURES PLANT MACRONUTRIENTS

B Hood, E Gardner, C Beal

Abstract

A trial of urine separation has been installed in a residence in South East Queensland and preliminary results are reported have shown that substantial amounts of macro nutrients at high solution concentration (2400mg/L for nitrogen, 480 mg/L for potassium and 140 mg/L for phosphorus) can be recovered whose mass approximates the agronomic needs to produce 200kg of grain per person every year. Other issues discussed pertinent to the safe reuse include human pathogens and trace organic pollutants as well as toilet use behavior and social acceptance. The latter has been largely positive to date not withstanding some odour issues from the under house storage bladder.

Introduction

The Ecovillage, a new development at Currumbin, Queensland, has communal treatment of sewage for around 110 detached dwellings of the total 144 allotments at the site. Energy saving at this development will be particularly important as the aim for the whole development is to achieve zero draw from grid electricity by using solar generation and energy efficiency measures in water and wastewater systems.

The body corporate was approached by the Queensland Department of Natural Resources and Water (NRW) with a proposal to participate in a trial of urine separation and researchers established contact with interested parties and prepared brochures and information packages outlining the nature of the study, highlighting the benefits of urine separation to the users. Extensive discussions with the voluntary participants were conducted prior to formalising agreements with each household. Discussions were also

This paper is a much reduced version of the paper presented at the On-Site and Decentralised Sewerage and Recycling Conference, Benalla, October 2008.

Figure 1. The wall mounted Gustavberg urine separating toilet at an Ecovillage home showing the urine weir at the front of the pan, urine collection pipe and the main waste with the water seal.

conducted with the Queensland Environmental Protection Agency, Queensland Health and the Gold Coast City Council. In the event, twenty were agreeable and.one house was selected for the initial trial.

The willingness of the residents at the Ecovillage to consider urine separation and reuse is an important consideration for this trial, making this study a unique opportunity.

Proposals for the trial were summarised in Beal *et al*., 2008.

Materials and Methods

The toilet supplied by the NRW to the participating residents was a Gustavberg urine separating unit that was selected on a number of criteria to maximise the benefit of urine separation. These include:

- low flush volume, 0.2 litres per half flush
- easy to clean
- lack of specialised moving parts
- compatibility with Australian plumbing fittings
- accessible urine pipe for clearing of blockages
- ability to collect urine while men urinate while standing
- minimal metal components in contact with urine
- comfort and ease of use (Beal *et al*., 2007).

Direct nutrient recycling is more sustainable and also saves energy.

Installation

The first toilet, one of the proposed 20 urine-separating toilets at the site, has been installed in a new residence. The toilet was connected to a 300 litre polyurethane storage bladder via 50 mm polyethylene pipe. The storage bladder was located under the house as close as possible to the toilet while still allowing access for sampling and emptying. Polyethylene fittings were used to minimise scaling problems from struvite deposition, which can occur when using metal pipes, and also to comply with local building covenants. Sufficient fall was incorporated in the collection pipes of 1 in 60 to allow the urine solution to drain to the storage vessel. The toilet was a wall mounted wet design that incorporates a P-bend water seal in both the main waste from the pan and the urine pipe. The wall behind the toilet must also contain the plumbing for both the main waste and the urine pipes so in this residence a plumbing space was incorporated in the wall behind the toilet. The wall behind the toilet unit was also appropriately braced with extra noggins to provide a solid mount for the cantilevered toilet, and the waste pipes were routed to clear any floor joists or electrical cable trays.

To separate urine from solids, the pan has an in-built weir at the front of the conventional pan to collect and drain urine to the storage bladder. The flush is dispersed in a normal manner through a flush rim that encircles the entire pan area. The cistern was a dual flush system of 2/4 litre volume and the half flush was not isolated to the front of the pan. The urine separating toilet is shown in Figure 1 as it was installed in the residence.

Figure 2 shows the plumbing connection to the storage bladder as installed.

Measurements

The urine solution was sampled at intervals that coincided with bladder pump-outs by vacuum truck, usually at 4-5 weeks intervals Three replicates of the separated urine were analysed to determine the total nitrogen, total Kjeldahl nitrogen (TKN), ammonium, nitrates, nitrites and total phosphorus as phosphate were also determined. Measurements of pH and electrical conductivity were also recorded at the time of sampling. The urine solution was also analysed for the concentrations of the metal cations potassium, sodium, calcium and magnesium and this allowed the calculation of the sodium adsorption ratio (SAR).

The toilet was calibrated to determine the volume of flush water that enters the urine separation plumbing. Volumes were 200 mL for a half flush, and 400 mL for full flush. Two cistern-mounted magnetic proximity switches and a digital counter record the number of full and half flushes.

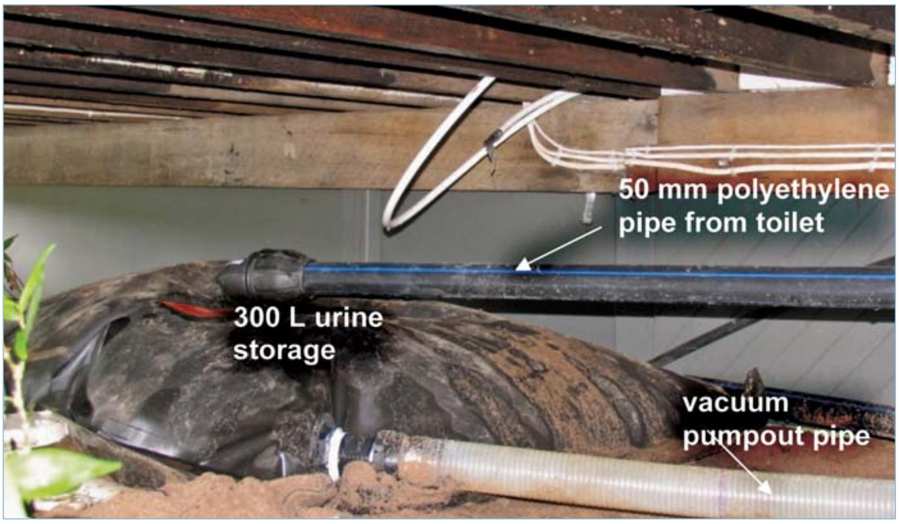

Figure 2. The 300 L urine storage bladder (full) under the residence showing the urine collection pipe and the reinforced vacuum pumpout hose for emptying the bladder.

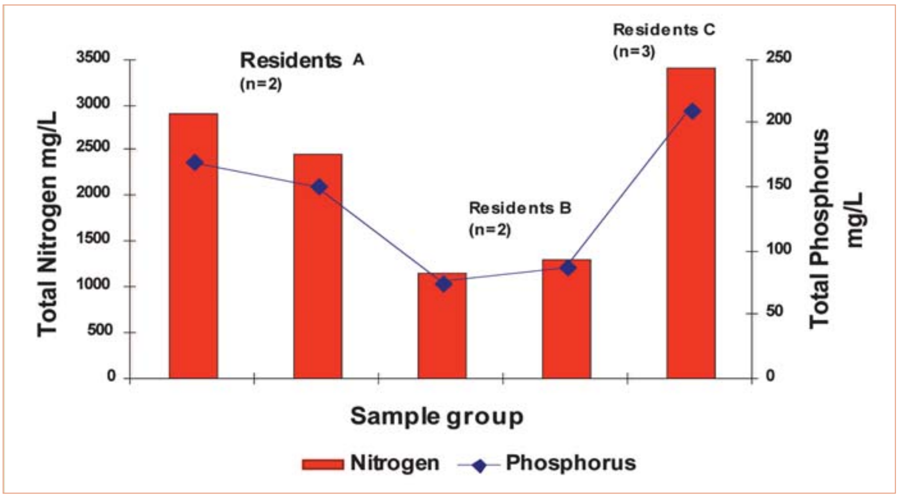

Figure 3. The comparison of the total nitrogen and phosphorus concentrations of the separated urine.

The volumes of the diluted urine solution were measured by means of a water meter connected to the suction pipe during pump-outs. The reinforced hose that connects between the storage and the pump truck is clear to allow the tester to see that the hose is full and ensure that the meter reads the correct volume.

The calculation of the volume of flush water allows the volume of raw urine to be determined by subtracting of the flush volume from the total volume measured during pump out.

Table 1. compares the concentrations in the urine, diluted with flush water, with full strength urine as reported by Johansonn.

Sample	units	1	2	3	4	5	Ave	Urine*
Tot N	mg/L	2927	2483	1153	1318	4014	2380	9200
TKN	mg/L	2787	2440	1143	1300	3333	2200	-
NH4	mg/L	2683	2377	1068	1250	3197	2115	581
NOx	mg/L	140	43	10	19	680	178	-
Total P	mg/L	170	150	75	87	211	138	720
Ca	mg/L	6	9	10	8	9	8	170
Mg	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	100
Na	mg/L	685	744	393	407	623	570	2200
K	mg/L	608	456	344	355	656	484	3300
SAR	nil	72	65	33	37	54	52	33
pH	nil	8.7	9	9.3	9	9	9	6.2-8.2
Elec. Cond.	μScm^{-1}	17000	17000	8200	9700	20230	14360	-
Volume	L/pp/day	4.7	2.9	2.4	3.8	1.9	3.1	1.25

**Data compiled from Wisenach et al. 2002 and Jonsson et al. 2004.*

Results and Discussion

Nutrients

The results obtained to date relate to one UST with three different sets of residents measured over five sampling occasions. The storage was emptied prior to each new set of tenants. The variation between sampling events was substantial as shown in Figure 3. The dominant form of nitrogen present in the storage was ammonium with an average concentration of 2,115 mgN/L with a range between 1,100 mgN/L and

3,200 mgN/L (Table 1). Nitrates and nitrites were present at a combined average concentration of 178 mgN/L. The TKN concentration was 2,200 mgN/L (vs 2115 mg/L of ammonium-N) indicating only a small amount of organic nitrogen was still present in the solution. These results are as expected as urea is readily hydrolysed microbiologically and promoted by the alkaline conditions that accompany the reaction (Jonsson *et al.* 2004). However anoxic conditions do not favour the conversion of ammonium to nitrate.

The average (total) phosphorus concentration was 138 mg P/L and varied between 75 and 212 mgP/L. Concentrations of the major cations in fresh urine were included for comparison in Table 1. Calcium (8 mg/L) and magnesium (<0.5 mg/L) concentrations are two orders of magnitude less than sodium (570 mg/L) and potassium (484 mg/L) concentrations, but display less variation between sampling events. The sodium adsorption ratio (SAR) of 52 was averaged over all sampling events. The pH of the stored urine solution remained strongly alkaline and averaged 9.0, whilst the average electrical conductivity was 14,360 μScm^{-1} (about 9000mg/L TDS).

The nitrogen available from the urine solution at the Ecovillage is around 3 kg/person/year based on the average concentrations and the generation of urine solution to date. Table 2 shows the comparison between the measured values in urine from the Ecovillage, and the crop requirements for producing 200kg of grain.

As can be seen from this table the solution at Currumbin may not be optimal for wheat, however other crops may be more suitable.

However significant challenges exist for the widespread use of urine.

Salinity and pH

The solution, with an electrical conductivity of 14360 μscm^{-1} and an SAR of 52 would be considered too high for irrigation, however small frequent doses of the fertiliser solution followed by deep irrigation would minimise the risks of salinity and sodicity.

The pH of the stored solution was around 9 so that volatilisation of ammonia would occur. Standard agronomic practice suggests that deep placement in moist soil with a fair cation exchange capacity will limit these types of losses (Johanssen *et al.* 2000). Irrigation following surface application of urine would seem to achieve most of these requirements.

Table 2. Nutrient loads and crop requirements for wheat.

Nutrient	Urine solution kg/p/yr	Nutrients (kg) contained in 200 kg grain
N	3.1	4.5
P	0.2	0.6
K	0.7	1.0

Struvite

Phosphorus in hydrolysed urine can precipitate as struvite, $MgNH_4PO_4.6H_2O$, particularly if metal piping is used in the collection system causing blockages in pipes and a potential loss of nutrients, as reported in European studies. In this study struvite precipitation was very low in the 50mm polyethylene piping.

However the very low concentrations of Mg and Ca in the urine solution compared to undiluted urine (Table 1) strongly suggests these cations have precipitated in phosphorus compounds (struvite and hydroxyapatite, Udert *et al.* 2003) in the bladder.

Pathogens

Urine is not sterile, and pathogens and benign micro-organisms occur. These organisms can include the normal enteric microflora such as *Escherichia coli* and *enterococci* spp., dermal bacteria like *Staphylococci* spp. or opportunistic pathogens such as Chlamydia and a range of viruses. This occurrence raises concerns for the end use of the urine solution and some form of treatment will be needed. The studies conducted in northern Europe have shown that urine can be effectively sanitised by storage for a period of six months with an average temperature of 10°C. A study is currently underway to measure microbial die-off at a range of temperatures and urine concentrations.

Further, the concentrations of faecal sterols such as coprostanol will be analysed to determine the potential faecal contamination and the associated viral load of the solution (Stewart *et al*.2007, Jonsson *et al*., 1997).

Micropollutants

Lienert and Larsen, 2007, Pronk *et al*. 2006 and Escher *et al*. 2006 have conducted recent studies into the issue of pharmaceuticals in separated urine in northern Europe. Lienert and Larsen 2007, state that up to two-thirds of all pharmaceuticals are passed in urine although the route of excretion is often dependent on the individual compound.

Ensuring that the urine solution will comply with conservative Australian standards and guidelines, for locally used pharmaceuticals and potential ecotoxins, will be a priority of the research team.

Social Acceptance

The voluntary participants were surveyed to assess their environmental awareness (Dunlap *et al* 2000) particularly about the issues of using urine separation and use as a fertiliser. At this time the responses will not be published as the sample set of respondents is statistically far too small. However, a monthly checklist has established usage patterns of the toilets and any problems.

To date all the residents have been happy with the performance of the toilet (aesthetics, flush efficiency, odour, comfort, ease of cleaning) and there has been only one (external) odour issue reported.

An important factor in the setup that can affect the dilution rate of the solution is the behaviour of the users and the manner in which they use the toilet flush. Many users may not flush every time they use the toilet especially when they have only passed urine and this would tend to concentrate the urine solution. However, different users, including visitors, may use the toilet differently, flushing the toilet at every use.

Three groups of users have resided in the dwelling to date and the rate of fill of the bladder has varied with each group. The normal pattern of use appears to be that the half flush is used each time urine is passed and the full flush is used when faeces are passed. With this pattern of use, the bladder fills in approximately 5 weeks. However, one group of users have reported that this particular toilet is efficient enough to use the half flush to remove solids. The fill rate of the bladder with these users has been much slower than with previous users with the bladder not filled after six weeks.

Conclusion

There are several benefits that may be possible with the adoption of urine separation and the reuse of the solution. Separated urine is rich in plant available forms of nutrients such as nitrogen, phosphorus and potassium and reusing a product that is normally considered a waste can lead to energy savings in production of these nutrients and in their removal from wastewater streams. Careful engineering of urine separation and storage systems can reduce the unpleasant aspects associated with this product and losses of the valuable nutrients. Other barriers such as microbial contamination of urine also requires the users to be aware of the risk factors of using human physiological wastes but solutions are being actively sought to enable the safe reuse of separated urine. A further challenge is the small but possibly significant amount of micropollutants such as pharmaceuticals and their metabolites. However the "yuk" factor may still be the greatest challenge to wider applications of urine separation, in spite of strong support to date at the Ecovillage at Currumbin.

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Barry Hood was responsible for running the trial in 2008 and is a research scientist at the Queensland Department of Natural Resources and Water in the Water Cycle Sciences group (email Barry.Hood@nrw.qld.gov.au). **Ted Gardner** is the Principal Scientist of the group and Adjunct Professor at Queensland University of Technology. **Dr Cara Beal** is also a research scientist in the group who initiated the project in 2007.

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URINE-SEPARATING DRY TOILETS AT MARYBOROUGH, VICTORIA

J Crockett, E Daniels

Abstract

A trial of urine-separating dry composting toilets at the Maryborough Education Centre in central Victoria is attempting to demonstrate the benefits of moving towards more sustainable sanitation methods. Preliminary results are reported.

Introduction

The project was a result of local community pressure and was based on the encouraging results of a study of the feasibility of use of dry toilets in schools for the Victorian Department of Education and Early Childhood Development. The waterless toilet block, housing six Rotaloo® urine-separating composting toilets and two waterless urinals, was opened in April 2007 and has operated for over 250 school days. It is one of 5 student toilet blocks at the school.

The project is being funded in part by a $170,000 grant from the Smart Water Fund, an initiative of the Victorian government and the Victorian water industry that supports the development of innovative water conservation, water recycling and sustainable bio-solids solutions. GHD and other participants have also contributed substantially to the project. A report for the Victorian Smart Water Fund (GHD, 2003) reviewed much of the work on urine separation and composting around the world.

The final report on the project will be available in mid-2009.

Facility Description

Figure 1 shows the toilet block and its greenhouse-type west-facing structure. The three pipes pointing up from the ground on the right are from an in-ground biofilter, which removes odour from the urine and leachate tank vents. The three pipes exiting the roof are the vents from the composters. Figure 2 shows the basement below the toilet rooms with three Rotaloo® Maxi 2000 composters on the left, the grey PVC 2 700 L leachate tank to collect liquid drained from the composters in the centre (in the floor) and the edge of the black HDPE 4300 L separated urine tank on the far right.

Figure 1. General view.

Figure 2. Basement.

Figure 3 shows one of the urine-separating pedestals. There are two pedestals connected to each of the three composters with 4 pedestals in the female toilets and two pedestals in the male toilets. Within each of the three composters are 8 triangular compost bins sitting on a carousel. Two bins are active at any one time. There are two waterless urinals in the male toilets and these drain directly to the urine tank. Urine pipework from the pedestals comprises 25 mm flexible PVC hose connected to 100 mm graded PVC pipework visible in Figure 2. There are inspection openings at each bend in the rigid PVC pipework.

The separate collection of urine keeps the compost drier and also reduces the nitrogen-to-carbon ratio to a more optimum value for composting. The drier compost is more permeable to air and this should help the composting process.

Ventilation is an important part of the process. 17 W electric fans on each composter discharge vent maintain a flow of air down through the toilet pedestals to prevent odour in the toilet room and also draw air in from the greenhouse. Wind-driven fans in the vent cowls also provide some air movement. Timers control the electric fans so that energy use and the cooling effect of air is minimised over night.

Results to Date

Data collected on the toilet installation

Overall, the project has demonstrated that such toilets are workable in a school, are odour-free for users, are readily kept in a clean state and that there are no obvious increased health risks compared to conventional water-flush toilets. However there have been several instances of smouldering and one minor fire within the compost bins caused by students dropping lighted material down the pedestals.

Significant achievements so far.

Usage has been much lower than the expected 200 uses by students and staff per day. Actual use has averaged fewer than 3 student uses per day, with negligible use by staff. The reasons for this include the location of the toilets at the far end of the school and bad behaviour by some students around and in the toilets that has discouraged use by others.

A significant quantity of data on airflow, air humidity and air and residue temperature has been collected. The literature to date has not included such information. Airflow and evaporation appear to be the main cause of heat loss from the composters.

Figure 3. Urine-separating dry toilet pedestal.

Airflow into the open pedestals has been measured on several occasions and was estimated to be typically around 0.24 m/s (range 0.18 to 0.3 m/s), which equates to airflow of 23 m^3/hr down the 185 mm diameter pan outlet. This has proved adequate (and possibly more than adequate) to positively prevent odour release into the toilet rooms.

Figure 4 shows the temperature history of the compost. The compost has shown no sign of generating heat to date and its temperature has closely followed the temperature of the air.

Fly breeding (of the common vinegar fly often found in compost) has only been noted on one occasion, possibly due to the low use and desiccating conditions.

It has been particularly pleasing to observe that the toilet pedestals have remained clean and (with the exception of one damaged seat) undamaged throughout the trial despite considerable damage to the building itself. The cleaner reports that it is easy to keep the toilets clean and he is certain that there has only been odour within the toilet rooms when fans have been off.

Figure 5 shows the air temperatures at the discharges of composters. High temperature is achieved in hot sunny weather when inlet air from the greenhouse can reach temperatures of over 50°C. A heater was placed on one of the composters (F2) in June 2007 and after overcoming control system problems it has been maintaining temperature at the discharge of this composter at around 20°C. Note that in winter there is little benefit from the greenhouse, partly as there is no provision for storing heat energy accumulated during the day and using it to keep the air stream warm at night. For much of the trial, the ventilation fans have been turned off at night to conserve energy and heat but this was stopped in May 2008 which may explain slightly lower temperatures in August 2008 compared to August 2007.

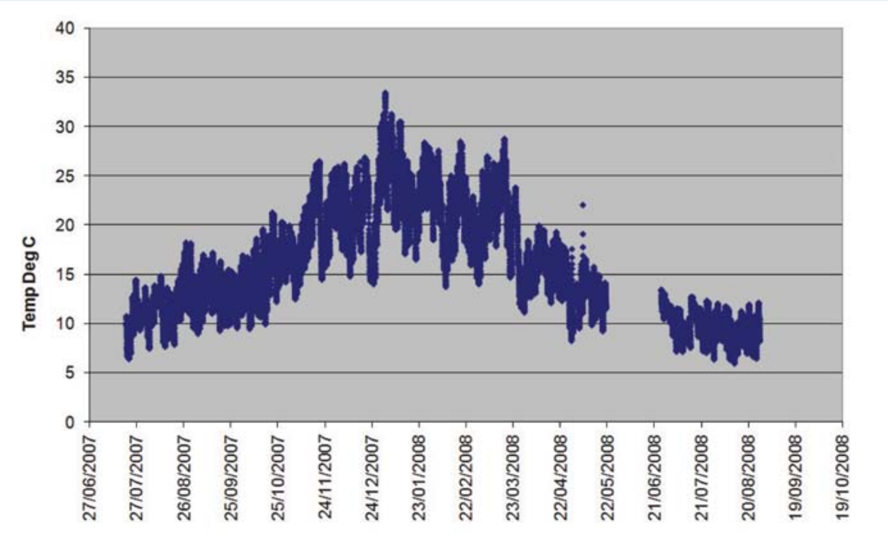

Figure 4. Temperature of 'compost' in one of the bins.

Urine tank temperature has also been monitored and it has ranged from a minimum of 10°C to a maximum of 27°C. This indicates some possible benefit from the greenhouse although, to keep the urine at the highest possible temperature which is thought to aid pathogen die-off, it would probably be desirable to provide both insulation and a means of getting additional heat into the tank from the greenhouse.

Psychrometric calculations on the air stream indicate that heat loss from each of the composters is probably of the order of 250 W and does not exceed 500 W. In fact, the heater installed on F2 has a 500 W element and it has been able to maintain temperature in F2. Water evaporated is estimated from the same calculations to be possibly up to 2 L/d. Water addition has been up to 3 L/d per composter to control moisture but despite this, compost has still remained in a desiccated state.

It is concluded that the current air system and greenhouse does little to keep the compost material warm in cold periods but it does generate effective desiccation. This desiccation is probably preventing any significant composting.

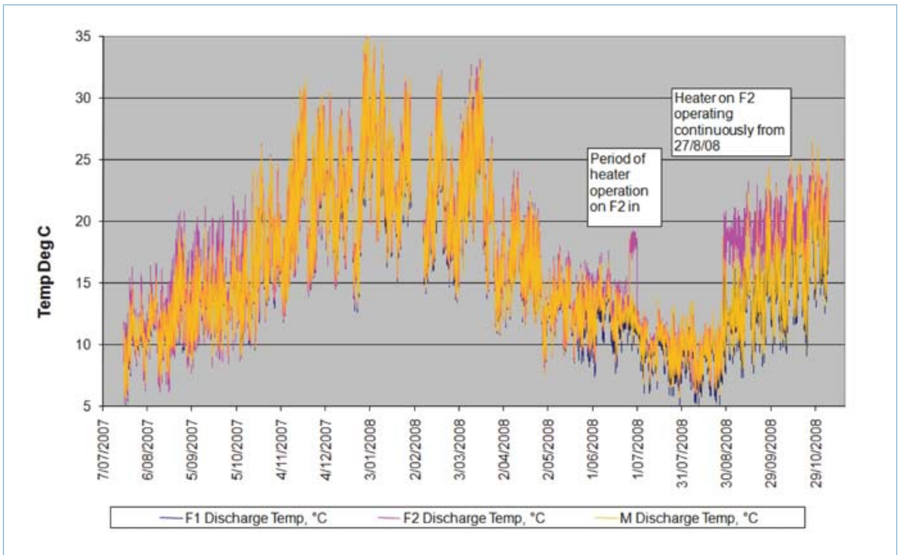

Figure 5. Air temperatures at composter discharge.

Cost

The cost of the toilets was expected to be high as construction was slab on ground over rock. The greenhouse structure was also costly. As well as this a number of items were included specifically for the trial. Thus the additional cost was $24,000 per fixture, much more than estimated for a large permanent scheme (GHD 2003).

Improvements could be made to the design to reduce cost, energy use for fans and to simplify the system. It is probable that, with urine separation, composting in-situ will be difficult to achieve as solids are rapidly desiccated. This makes it doubtful that the costly greenhouse structure provided is necessary. One simple option would be to provide only one or two small bins for solids from each pedestal and to remove desiccated solids regularly to a central controlled composting facility. This would significantly reduce the cost of below ground equipment and structures and probably give better results in terms of fly, odour and health risk control.

Urine and Leachate Quality and Salt Impact

Table 1 shows the quality of leachate and separated urine collected in the trial based on two rounds of sampling. The first round data were estimated from measurements (to allow for some initial water in the tanks). When compared to published concentrations in urine (GHD 2003), these concentrations for urine are of a similar magnitude.

The collected urine is dark brown in colour and contains relatively soft sheet-like pieces of what appears to be chemical scale from the tank surfaces. It has a strong, sharp and unpleasant ammonia-amine odour. Leachate is more dilute as a result of regular addition of water to the compost bins to maintain moisture content and minimise the risk of fire.

Table 1. Available Analyses of Urine and Leachate.

Analyte	Units	Estimated Leachate Composition 27/8/08	Estimated Urine Composition 27/8/08	Leachate sampled 6/11/08	Urine Sampled 6/11/08
pH		6.5	7.8	4.5	7.7
Specific Gravity		1.0006	1.0171	1.0064	1.0134
Calcium	mg/L	74	45	82	26
Magnesium	mg/L	161	3.6	170	1.9
Sodium	mg/L	1406	3221	1400	2300
Potassium	mg/L	864	2653	900	2000
Bicarbonate Alkalinity as $CaCO_3$	mg/L	121	4926	<10	3000
Carbonate Alkalinity as $CaCO_3$	mg/L	0	0	0	0
Chloride	mg/L	2813	5874	2900	4000
Sulfate	mg/L	693	1800	750	1200
Total Solids (Evaporation at 105°C)	mg/L	8237	28421	7300	15000
Suspended Solids	mg/L	683	493	180	1500
Fixed Total Solids	mg/L	6830	14211	6000	9600
Total Dissolved Solids (105°C)	mg/L	6830	28421	7000	14000
Organic Total Solids	mg/L	1406	14211	1300	5200
Conductivity at 25°C	uS/cm	11049	49263	11000	31000
Kjeldahl Nitrogen	mg/L	151	3221	110	2300
Ammonia as N	mg/L	121	436	76	1800
Organic N	mg/L	31	2842	30	530
Nitrite as N	mg/L	16	17	14	750
Nitrate as N	mg/L	77	2274	100	1200
Total Oxidised N	mg/L	93	2274	110	2000
Total Phosphorus as P	mg/L	14	360	14	250
Ortho Phosphate as P	mg/L	11	322	12	200
E. coli	per 100 mL	131	<19	<10	<10
Faecal *Streptococcoi*	per 100 mL	30	230000	<10	<10
Total Viable Aerobic Count	per mL	100446	1080000	1800	5000

None of the metal concentrations exceeded guidelines for irrigation water.

The Agricultural Trial

The urine and leachate was sucked out of the tanks by a conventional eductor truck and carted 20 km to the agricultural trial site. Approval was obtained from various parties on the basis that the materials applied would meet quality requirements in guidelines published for biosolids application and provided access to the site was limited. Any large scale application will require development of specific guidelines and rules.

The 585 L of urine and leachate collected was placed in a 600 L storage tank at the farm. Half of this was pumped into a 440 L water tank on a utility and diluted with bore water. This was then sprayed onto a 98.8 m^2 pasture plot. Odour was appreciable but did not last for long. A further 440 L of water was applied to wash the material from the pasture plants. This process was repeated with the remaining half of the material on a plot of growing canola. The plot area was set to give a nitrogen application rate of 50 kg N/ha, based on advice from the farmer and the local fertiliser supplier. Applied phosphorus and potassium on the urine/leachate plots was 4.85 kg P/ha and 34.6 kg K/ha. Two control plots were fertilised with chemical fertiliser to give similar loading rates and these had 440 L of water applied to wash chemical from the plants. Two unfertilised control plots were also used. Soils on the trial areas were tested prior to and after the trial and results will be reported in the final report. The response of the canola was determined by counting pods and seeds per pod, by measuring plant heights and by weighing the crop. Response of pasture was measured by cutting and weighing. There appeared to be a visible and measureable response on both the pasture and canola with the urine/leachate canola plot showing a statistically significant response compared to the control plot and possibly the chemically fertilised plot.

Figure 6. Urine-fertilised canola plot on final day of trial (day of harvest). Tape is 1.2m high.

The calculated sodium absorption ratios are approximately 20 for leachate and 120 for urine. There was no obvious impact on the plants or soil in the agricultural trial. The sodium load applied was only around 140 kg/ha which is probably less than is applied annually on most irrigation plots.

The results from the agricultural trial indicate that application of urine and leachate to growing canola and pasture as fertiliser is feasible.

The materials were easily collected, transported and applied. Figure 6 shows the canola plot at the conclusion of the trial.

User Survey Results

Two user surveys have now been completed. The first, prior to opening of the toilets, indicated a low level of knowledge of composting toilets but considerable agreement that the water and resource-conservation benefits made sense. There was a significant indication that some people (more females than males) would not use the toilets as they regarded them as inferior or undesirable. The second survey showed that only around 25% of students and staff have used the toilets (17% of females and 35% of males). However, the majority of those using the toilets have found it either not as bad as they expected or were pleasantly surprised by the experience as indicated in Figure 7. Many students indicated that they did not use the toilets because smokers use them. This is a significant confounding factor in the overall project that is not related to the type of toilet but the location in the school and the behaviour of students.

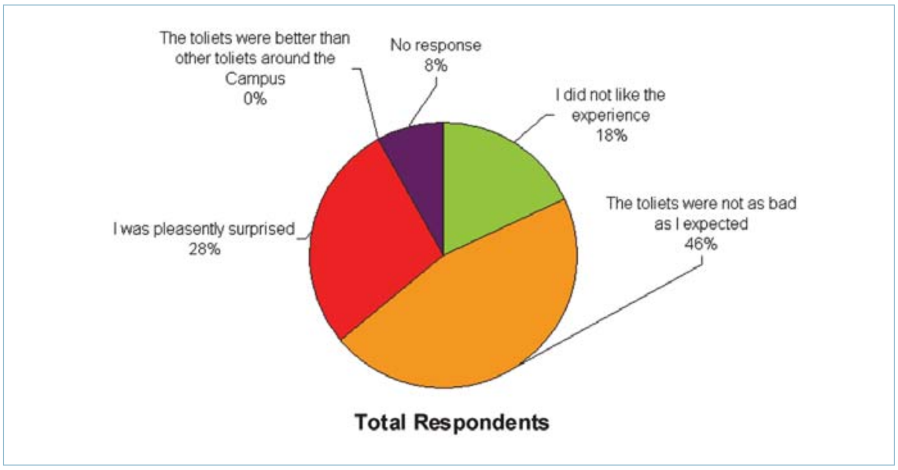

Figure 7. User reactions from the second user survey.

Conclusions

Increasing acceptance by students, absence of odour in the toilet rooms, absence of fly nuisance, saving of at least 5 kL of water and successful demonstration of the fertiliser potential of separated urine have been the significant achievements so far. There is still prejudice against “different” toilets and composting toilets in particular suffer from some stigma as they are often equated to pit latrines or composting toilets in remote locations which are rarely, if ever, cleaned.

The overall conclusion from the trial so far is that urine-separating dry composting toilets of the type installed at Maryborough is an acceptable, safe and effective sanitation option for a school and for wider application. Water is saved and resources can be recovered, probably for no additional energy use compared to conventional sewerage. Odour is effectively contained by use of fans to the extent that the toilet rooms have no odour. The pans can be kept clean readily and absence of flushing does not make the insides of the pedestals unpleasant. Urine and leachate can be applied to growing crops with benefit. However, much needs to be done for such toilets to gain wide acceptance by users. Guidelines and regulations need to be developed to provide for beneficial use of the recovered resources.

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Reference

GHD, December 2003, Composting Toilet Demonstration Feasibility Study, Report to the Smart Water Fund, Victoria, can be downloaded from GHD’s website using the following link: http://www.ghd.com.au/aptrixpublishing.nsf/Content/CompostingToilets_prj.