Greywater appears to be an answer – but to what question?

Presented as an oral presentation by

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At New Zealand Land Treatment Collective Annual Conference
(Technical Session 32)

A conference in cooperation with the Small Wastewater and Natural Systems Special Interest Group of Water New Zealand

Conference theme "Wind of Change: Land treatment in challenging times"

Held at
Palmerston North Convention Centre
23rd – 25th March 2011

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ABSTRACT

While it has been fashionable to consider the reuse of household wastewater as a potential beneficial product, some proponents expect a mystical outcome from such actions. Greywater may be a substitute for scarce clean water in the garden, but the additives derived from domestic use must be considered. A simple investigation of over 100 chemicals in use in a 'typical' household is nearly enough to shake one's head in disbelief. Given today's chemical wizardry, how could anyone suggest that the uncontrolled or indiscriminate use of greywater will not have a detrimental impact upon our soils and the soil ecosystems?

Recent research by Lanfax Laboratories of Australian and New Zealand household chemicals has shown that the simple chemistry of greywater from laundries is sufficient to impinge upon the germination of seeds, the loss of soil permeability, the flushing of humic colloids from the soil profile and the loss of structural stability in susceptible soils. Rather than legislate on the reuse of greywater to minimise the environmental implications of its use in a domestic setting, regulators would be better rewarded by targeting specialty chemical manufacturers to encourage them to alter formulations to have less of a detrimental impact upon the environment. A recent law change in NZ went part of the way to meeting that need for environmental and human protection. Dishwashing detergents must now have, when mixed at 1:1 with water, a pH less than 10. Why? Serious injury was inflicted on a young boy when he ingested a small amount of a dishwashing powder. Simple, if you cannot protect the person or environment, change the product.

This paper will provide an insight into the simple chemistry of household products and offer alternatives towards making products less environmentally hazardous; a situation in which politician, the community and the environment can all be winners.

KEYWORDS: chemicals, detergents, greywater, recycling and reuse

INTRODUCTION

The separation of household wastewater into blackwater and greywater streams, so that the greywater can be used for gardening and other recycling opportunities, seems too good to let pass. Substituting drinking water with greywater for irrigation reduces the costs associated with clean water provision or requiring additional tanks for storing rainwater. However, domestic wastewater is not just a stream of uniformly polluted water; it is a stream that varies in flow, chemical properties, temperature and bacterial contamination. The complexities of designing for hydraulic and chemical loads seem to be overlooked in the race to save clean reticulated water during a drought, or reduce wastewater load on capacity-limited sewage treatment systems (on-site and municipal). Politicians typically pass legislation to "enforce" some pre-conceived idea on the basis that the community will do the 'wrong thing" – whatever that may be. Government agencies respond to develop guidelines based upon other pre-conceived beliefs (including myths and legends) and an industry buckles under compliance, training and inspections and possibly penalties. In the meantime, science takes a holiday for fear of further complicating the stage with facts and research outcomes.

So, for the politicians and their bureaucracy, what is the question that greywater seems so eager to answer? This paper will look at some of the answers that may challenge the various questions that could be asked of our leaders.

GREYWATER IMPACTS

Government planning issues

Not so long ago the Australian Government accepted Triple Bottom Line (TBL) accounting (Sugget and Goodsir 2002) that required conformity of planning issues in addressing: (1) environmental; (2) social; and (3) economic impacts of any proposed development. The purpose was to investigate the impacts and mitigate for favourable outcomes. Other countries had their own TBL principles. In New Zealand, the Minister for the Environment in October 2001 stated "*I have said that one of my objectives is to forge new alliances with green and socially aware business. The capacity for Government to work more effectively with business is one of the most exciting developments in the term of this Government. An example of working together is the Triple Bottom Line Project currently running in the Ministry for the Environment* (Hobbs 2001).

TBL was great for the community to know that a balance would be struck in developments and not just environment issues would be addressed. The community's social and economic wellbeing was also important. To assume that TBL would be considered before new legislation was written was probably expecting a bit much. To say that TBL has come back to bite all Governments and their agencies would be an understatement. Of course, TBL does not apply to government regulation, why should it? If it did, then the regulation of greywater would need to address the three issues. A quick look at the plethora of regulation and guidelines in Australia and New Zealand simply reinforces the absence of TBL principles.

Fashionable but contradictory status

Governments have been quick to embrace greywater reuse. In Australia, Federal and State Governments have guidelines to address the issue, but uniformity across the states is far from common sense. In New South Wales, just the 'activity' of placing a hose on the end of a washing machine, so that water can be discharged outside the laundry, is illegal. But it is okay to bucket the water to where ever you wish. That's if your back can stand it! In New Zealand, conflicting messages emanate from Governments. Auckland Regional Council (ARC) defines wastewater to include greywater and states "In order to discharge wastewater without a consent you will need to meet the criteria of one of the permitted activity rules" (ARC 2010). One of those consent conditions is that the wastewater will have secondary treatment (Rule 5.5.20). There the cost effectiveness of reusing greywater simply evaporates. So, does ARC favour greywater reuse or simply regulated its avoidance. Smarter Homes (2008) states "By re-using greywater instead of sending it down the drain, you can save water, reduce wastewater charges and cut down on demand for water supplies in your area". That purpose may be logical but at what cost?

The NZ Department of Building and Housing states "We consider that greywater could be recycled in commercial, industrial and other buildings where monitoring can take place as part of a compliance regime. But we do not consider that the management of greywater recycling in domestic buildings would be likely to provide adequate safeguards against disease transmission." What is the official policy on greywater reuse?

The author was recently asked (Berkowitz, *pers,comm*) to make comment on sections of the Draft USA Standard NSF 350 "Onsite Residential and Commercial Water Reuse Treatment

Systems". No reference, in the 42 pages, is made to the discharge of the water to land, and no reference is made to soil/water interactions. So why bother with standards for greywater?

If the question is "Is greywater reuse popular with governments? then the answer is "Yes, governments see greywater reuse as something they can regulate for the benefit of society". The second question is: "Are these regulations encouraging to widespread acceptance of beneficial greywater reuse? This answer is "No", they are discouraging, or at least making the issue confusing and only the committed (and wealthy) residents will persist.

Daily variability of flows

Another question: "Is the daily flow of greywater a useful volume of water?" The answer is definitely "Yes". A typical household's production of greywater comes from the shower, bath, handbasin and laundry and is generated every day. The hydraulic load can be calculated simply by taking the number of persons and their likely daily use from each of these fixtures. But what is the average time under shower for each member of the family? We hear disparaging remarks about teenage daughters spending long periods under the shower, but are teenage sons any different? Or for that case, mum or dad? What is the requirement for laundry services – one full wash per day, or several partly full washes, or six on Saturday? Top loader or front loader washing machine? So how do we design a universal guideline to deal with the highly variable hydraulic load, and account for rainfall at the same time? What do we do when rainfall has been so extensive that any greywater discharge will be surplus to the capacity of the soil to absorb? Either discharge to sewer or store on-site is the reply.

Figure 1 shows the changes to electrical conductivity (EC) of septic tank effluent from a five person household over two days, and the inflows of clean water (rainwater). Variation occurs when different activities add different chemicals to the system; dosing is not uniform. The result (Patterson, unpub.) was that the soil received water of varying EC, low EC following high EC and vice versa which may cause dispersion in the soil. The suggestion that a constant 'synthesised' greywater may replicate soil behaviour is flawed. Also, predicting the outcome of various soil types by treating soil with only laundry water is also flawed. Randomly dosing soils with clean water and laundry water may be required to calibrate a soil to its likely behaviour. The variation of soil across even a small area may require a prohibitively expensive, and futile, testing regime. The neighbouring property could be different again.

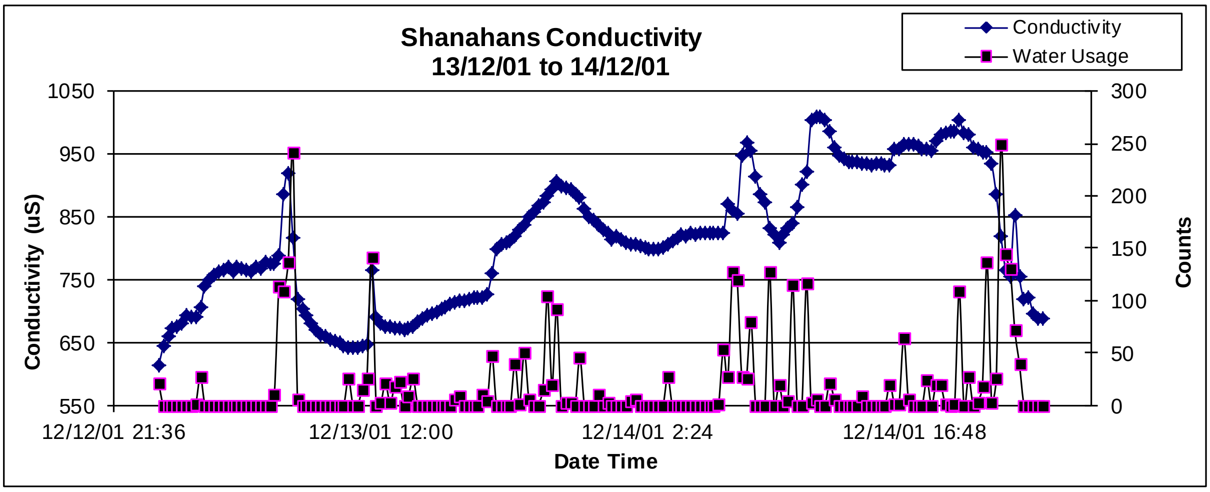

Figure 1. 15-minute variation in water inputs and electrical conductivity

As shown in Figure 1, the volume of water used has a bearing on the concentration of the chemicals, assuming chemical loads per operation remain the same; greywater quality is intricately tied to water use. Now the question is: "Can average daily water use be used to estimate likely requirements for land application areas? My answer would be: "No, each site requires its own calculation, which includes daily account for irrigation requirements". Therefore, either large wet weather storage or discharge to sewer is required. A simple solution would be for the regulator to provide guidelines for irrigation for specific areas.

Economics

The cost of greywater reuse will vary depending upon whether the wastewater is diverted or treated. Simple diversions still requires specialised fixtures and an irrigation scheme, the extent of which is dictated by the consent required. A question: "What is the cost of greywater reuse?" One needs to compare the cost of greywater diversion devices, greywater treatment system, together with irrigation field installation, against the cost of rainwater collection and storage. So, is the cost of greywater reuse cheaper than rainwater collection? The latter also reduces the impact on clean water production but does not limit the load on a sewerage scheme. If greywater reuse has a wider benefit to the community by reducing reliance upon scarce drinking water, then should a subsidy apply to greywater reuse?

GREYWATER CHEMISTRY

Researchers have attempted to devise synthetic greywater solutions that may be used to test the behaviour of soils under typical conditions. Daiper *et al*. (2008) suggest a prepared concoction of a range of household and personal care products that replicates what they suggest is the accumulated daily household discharge. Yet this greywater blend does not account for flows directly from the fixture to the irrigation area, but accumulates the daily flows. The essential ingredient is that the greywater is held during the mixing process until the daily volume is irrigated. Unfortunately, that is not usual for greywater discharge.

From greywater diversion devices (GDD), wastewater is distributed to the land area as it is received, maybe held until a pump volume is available. Greywater treatment systems (GTS) add a further step that is likely to modify the synthetic greywater – primary treatment, where some biological degradation is likely occur in the overall process of adding water to an already full tank and only irrigating the overflow.

Research by Tjandraatmadja *et el.* (2008) gives comprehensive analysis of common household chemicals, including the trace element contributions from a broad range of products, both household and personal care. The overwhelming evidence is that the range of elements in domestic wastewater is broad, but the contribution of the sodium load is highest from laundry products.

Research by Lanfax Laboratories (www.lanfaxlabs.com.au/laundry.htm) over nearly two decades reports on a range of household laundry products that contribute various chemical properties to wastewater from specific appliances and products. While concentrations may vary considerably because of daily water use, chemical loads may be small, at least for the bathroom and hand-basin. In the laundry, detergent use varies by brand, and chemical inputs, measured in grams per wash may cover a wide range as shown in Figure 2. Whether detergents are liquids or powders influences pH, EC, total alkalinity and sodium. Figure 3 shows the EC of 90 products, indicating that the EC of any wash is likely to vary because of brand used. Most liquid detergents have an EC < 0.5 dS/m.

Substitution by greywater

A pertinent question is: "Can greywater be a valuable substitution for clean water for irrigation in home gardens?" The short answer is "Yes, but…..". Firstly, a better system of consumer education of the greywater/garden impacts needs to clarify the constraints, rather than just opportunities. Such education can only come from regulation of the manufacturers of household chemicals and laundry detergents. That will not be easy because these moguls of clever advertising are working a billion dollar business where, up until now, they have marketed a product under an environmental awareness banner that should not apply. For example, the term 'biodegradability' only applies to the surfactant in the detergent, generally less than 25% of the contents of the pack. Unfortunately the remainder of the contents may have significant detrimental effects upon the plants and soil; interestingly many greywater guidelines avoid discussions about the soil. The NSF 350 only uses the term 'soil' twice in a 42 page document and does not discuss sodium at all – useless guidance for consumers.

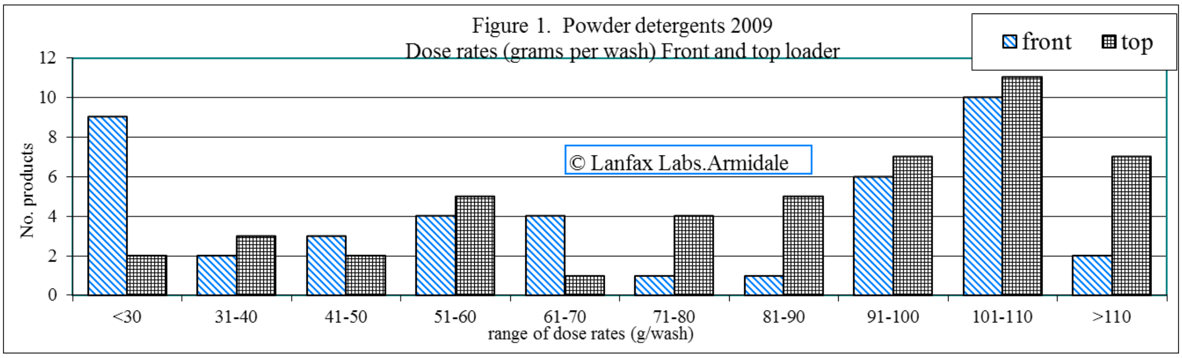

Figure 2. Variations in laundry detergent use by dose per wash

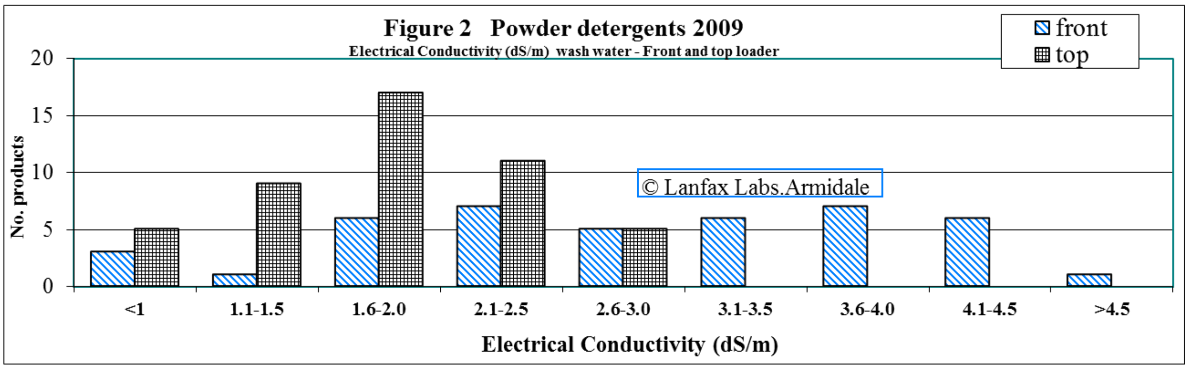

Figure 3. Variation in EC for a range of powder products.

SOLUTIONS

Labelling of products

A recent compensation case in New Zealand arose when a child swallowed automatic dish-washing powder (NZ Herald 2007). The regulator seized the opportunity and limited the pH of all automatic dishwashing products to less than pH10 when mixed 1:1 with water. Governments have power over the household chemical manufacturers and retailers, when they see fit to use it. Why then do governments shy away from regulating other household chemicals known to be detrimental to reuse at either the on-site or the municipal level? We patiently await an answer that satisfies the environmental, social and economic parts of TBL.

Performance testing of dose rates

The dose of laundry detergent varies considerably from product to product. Choice (Aust) and Choice (NZ) test the performance of detergents against a standard. In 2010, Choice (Aust) found that for the leading brand of detergent in Australia, which is also the leading brand in New Zealand under a different name, the performance from half the recommended dose was on a par with the full dose score. So why not reduce the dose with the resulting increase in wastewater quality (lower pH, lower EC, lower sodium). How hard is that?

“Leave it to the manufacturers for self-regulation” we hear. The industry-regulated phosphorus level is 7.8 g P per wash and a product with no phosphorus may have as little as 0.5%. But why remove all the phosphorus when it is an excellent ‘builder’ that cannot be replaced by another single chemical. That minimisation may suit municipal works that discharge to rivers and oceans, but for greywater reuse its distribution can be managed. The replacement of phosphorus compounds with artificial zeolite (Zeolite-A) results in a sediment settling in receptables, that may also block pipes and irrigation equipment. Is the Zeolite any better than the phosphorus? Perhaps the potential problems of algal proliferation are reduced, but other problems erupt, yet are not addressed.

CONCLUSION

The regulation of greywater reuse is widespread, with different jurisdictions taking entirely different approaches, all with supporting guidelines that make compliance difficult, expensive and doubtfully better for the environment or the community.

Highly variable flows of water and chemicals on a daily basis make the formulation of a ‘synthetic’ greywater a highly improbable test solution, difficult to replicate what actually takes place when greywater is discharged around the home. A real problem for soil behaviour is the changing status of discharging water with respect to EC and pH. High EC with high sodium, followed by low EC with low sodium is known to cause serious dispersion in clays but not in sands. Just how this effect is overcome is remove the chemicals that result in high EC and sodium. Simple! The question has been answered, greywater reuse is an option when only the clear guidelines for the home owner and manufacturers’ reformulation are in place.

REFERENCES

Choice 2009. Detergent Overdose. *Choice Magazine*. November 2009. Australian Consumer Association, Sydney. P4.

Auckland Regional Council 2010. Wastewater Rules. Accessed 23 February 2011 http://www.arc.govt.nz/environment/water/wastewater/wastewater-rules.cfm

Diaper, C., Toifl, M., and Storey, M. (2008). *Greywater technology testing protocol*.CSIRO Water for a Healthy Country National Research Flagship report CSIRO.

Berkowitz, Steven. (January 2011) (pers. comm.) Engineering Team Leader, On-site Water Protection Section, Division of Environmental Health North Carolina Dept. of Envir. and Natural Resources.

Hobbs, M. (2001) The Government's Commitment to Sustainability. Triple Bottom Line forum, Massey University Campus, Wellington accessed from http://www.beehive.govt.nz/node/12116 23rd February 2011

New Zealand Herald. 2007. Mother wins detergent restrictions. 30 June 2007.

NFS International. 2011. Onsite residential and Commercial Water Reuse Treatment Systems. Issue 1, Draft 2.

Tjandraatmadja, G., Diaper, C., Gozukara, Y., Burch, L., Sheedy, C., and Price, G. (2008). *Sources of priority contaminants in domestic wastewater: contaminant contribution from household products*. Water for a Healthy Country National Research Flagship report CSIRO.

Smarter Homes 2008. Re-using greywater. Website http://www.smarterhomes.org.nz/water/re-using-greywater/#toc_5 accessed 23 Feb.2011.

Sugget, D and Goodsir, B. (2002*) Triple Bottom Line Measurement and Reporting in Australia*. Report for Department of Sustainability, Environment, Water, Population and Communities. Downloaded 25th January 2011. http://www.environment.gov.au/sustainability/industry/publications/triple-bottom/index.html