Rimmer, Mr Tim (Presenter)

School of the Built Environment, Unitec Institute of Technology, Carrington Road, Mt Albert, Auckland.

Telephone: 8154321 x 8443

Email: trimmer@unitec.ac.nz, Home: timrim@ihug.co.nz

Sustainability as appropriate use of technology for on-site wastewater/used water systems – examples from Waiheke Island, New Zealand.

Category: Sustainable technologies and products.

Title

Sustainability as appropriate use of technology for on-site wastewater/used water systems – examples from Waiheke Island, New Zealand.

Tim Rimmer, Lecturer, School of The Built Environment, Unitec Institute of Technology, Carrington Road, Mt Albert, Auckland, New Zealand.

Abstract

On Waiheke Island failure of septic tank and disposal systems create environmental impact problems, particularly as the Island rapidly develops. The Regional Council is responding to such problems by tightening the criteria for permitted activities for onsite wastewater disposal. At the time of writing, this is largely taking the form of a 'one type fits all' solution based around technology that achieves excellent water quality outcomes. However, such technology can be viewed as being both resource and energy hungry and with its own wider environmental impacts.

This paper suggests that such approaches are not necessarily the most sustainable option for onsite waste and used water disposal. Inherent in sustainability are notions that wider social, economic and environmental effects need consideration, as such it is important that technology is used appropriately. The paper presents information from the monitoring of four alternative onsite systems on Waiheke Island. These comprise: composting/greywater, composting/greywater/reedbed, split septic tank/greywater systems and one involving full botanical treatment of both black and greywater.

I suggest such systems are examples of sustainable technologies that achieve good to excellent water quality outcomes, and are appropriate for both the site and in addressing wider social/environmental issues.

Introduction

Waiheke Island, located in the Hauraki Gulf east of Auckland City is currently the focus of much debate pertaining to disposal of household wastewater. The territorial authority (Auckland City Council) states that water quality in many of the Island's freshwater bodies fails to meet public health standards, and that the problem is due to a combination of failing septic systems and poorly draining clay soils, creating contaminated runoff. At present the Council sees the solution lies in reticulation to one or more treatment plants.

Over the last two years the Regional Council, the body governing environmental issues over the wider Auckland area, has consulted widely with regard to proposed changes to the Regional Air, Land and Water Plan. This has resulted in changes to rules governing permitted activities for on-site discharge of domestic wastewater, permitted activities being those requiring a building consent only form the territorial authority. Initially one system only was permitted, but now the criteria is broadened to incorporate any system that incorporates septic tank, outlet filter and secondary treatment process meeting certain water quality standards. The new rules exclude many alternative systems unless properties have very large areas for disposal or individuals apply for consent from the ARC.

A previous study makes a case for the wider acceptance of alternative systems, based on their ability to achieve required water quality standards. The paper also presents an initial attempt to rate such systems in terms of their performance relative to sustainability, (Rambeck and Rimmer, 2004). The present paper builds on this previous data. It presents information from initial monitoring of two other alternative systems and a more comprehensive look at sustainability performance. The latter information while somewhat subjective and incomplete, is presented to generate more debate on the need to incorporate sustainability factors for on-site wastewater /used-water treatment. Such data is useful because without it Council officers and regulators at local, regional and national level may remain uninformed on other available options. Such options not only achieve required environmental standards but also better address sustainability requirements and the needs of local people. This is important in light of current local Council initiatives to reticulate Waiheke Island and other areas. Recent papers are now questioning not only the ecological but economic sustainability of such approaches (Schertenleib 2004, Wilderer 2004).

Reticulation can be seen as inappropriate use of technology in certain instances, so too can various on-site systems utilising relatively expensive technology with a high resource and energy 'foot print'. If a simpler system is appropriate for the site, achieves equivalent water quality outcomes and is the landowner's preferred option, why should it be classed as a non-permitted activity, which then results in a relatively long and costly consent process through the ARC? The KISS principle is inherent in sustainability, for an on-site system it means not only 'keep the irrigation system shallow' but 'keep it simple son'. Sustainability links environmental, social and economic concerns, and makes use of appropriate technology.

This paper presents water quality data from initial monitoring of four alternative on-site wastewater/used-water systems. Each system is described, and results are compared with data from a permitted septic tank/recirculating textile filter system as shown in the latest version of the Regional Council's design manual – ARC TP 58. Comments are made first, on performance with respect to standard water quality and public health criteria: biochemical oxygen demand (BOD_5), total suspended solids (TSS), and faecal coliforms (FCU), second with regard to wider sustainability criteria. Both are combined within a basic matrix which is then used to give a rating for each system.

System Descriptions

Systems are on lots between 800 and 1200m2 in size, all are elevated, on 5-10 degree slopes with some native vegetation cover. Components of each are given in Table 1. Sketches of system layout are shown in Figures 1-4.

Table 1. System Details

SYSTEM -	AGE (Yrs)	HOUSEHOLD	COMPONENTS	DISPOSAL DETAILS
A	4.5	Two bedroom 4 people	Septic tank, macerating pump, 2 stage botanical wetland	Outlet manifold + 60m of LPED*
B	3.5	Two bedroom 4 people	Dry composting toilet – 'Toatrone', two greywater tanks + filter, 6m x 1m x 0.5m reed bed	Distribution Box + 3 x 12m LPED
C	1.5	Two bedroom 1 person	Wet composting toilet –'Aquatron', two greywater tanks + filter, UV unit.	Distribution Box + 4 x 11m LPED
D	> 10 1.5	Three bedroom 4 people	<u>Split System</u> a) Blackwater - septic tank + filter b) Greywater- two greywater tanks + filter, pump station	Distribution box + 3 x 8m trenches Distribution Box + 6 x 12m LPED

* LPED = Low Pressure Effluent Distribution – comprises 30mm diameter perforated pipe placed within 100mm diameter perforated draincoil, placed in shallow trenches. Lines connected to distribution box for gravity flow (as in A, B, C) or pumped flow (D).

System D is split into two components: a) blackwater from the toilet and kitchen enters the septic tank, and b) used-water from bathroom and laundry enters a two tank system, which pumps the greywater to a separate disposal field. The system was split to remedy poor performance of the septic tank and address Council concerns. There have been no subsequent problems and in this paper data is presented for the greywater system only.

Figure 1. Outline of System A –Two stage botanical wetland.

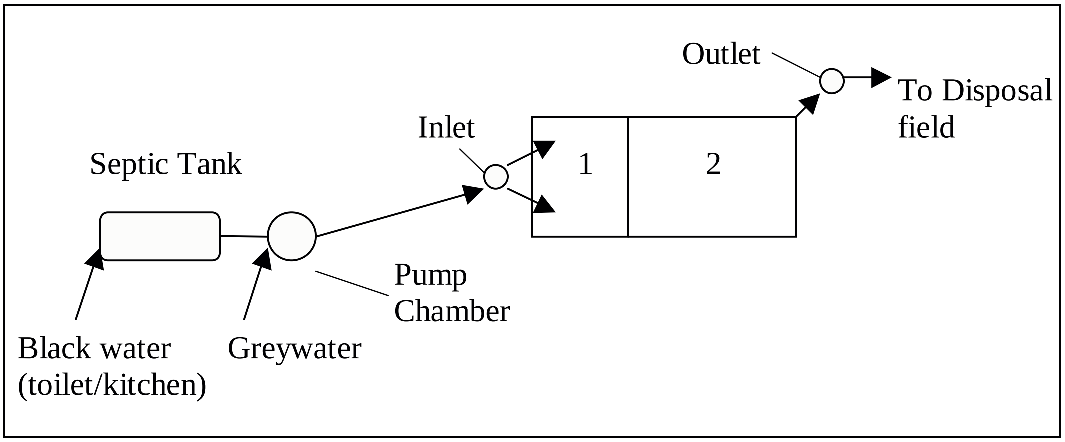


Figure 2. Outline of System B – Dry composting toilet, greywater tanks and reed bed.

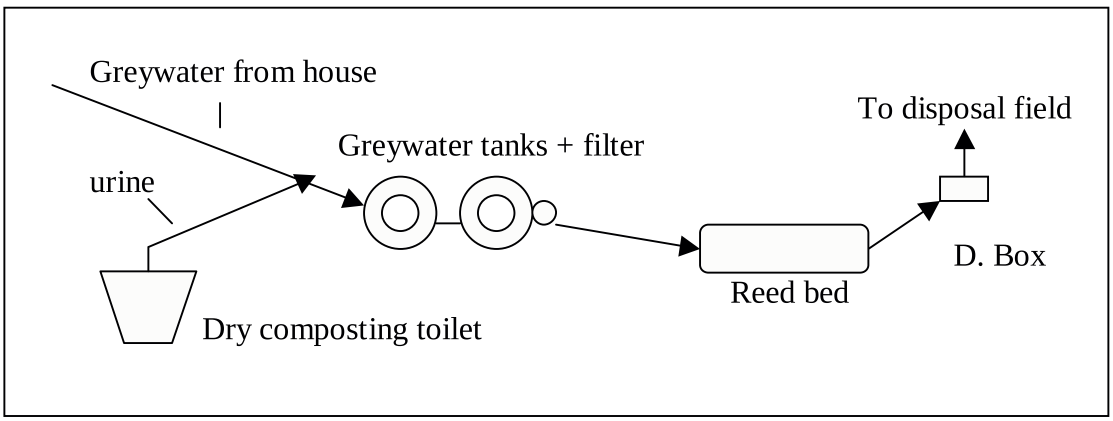


Figure 3. Outline of System C – Aquatron composting system + greywater tanks.

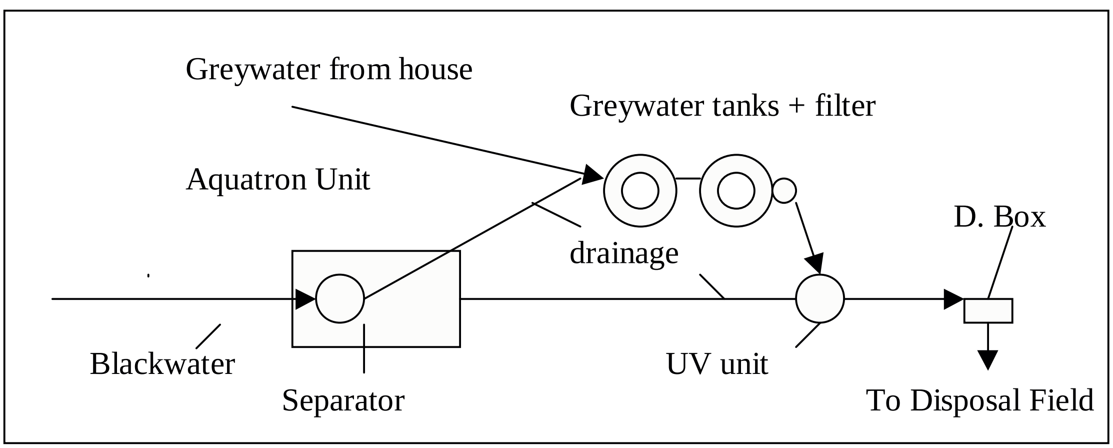
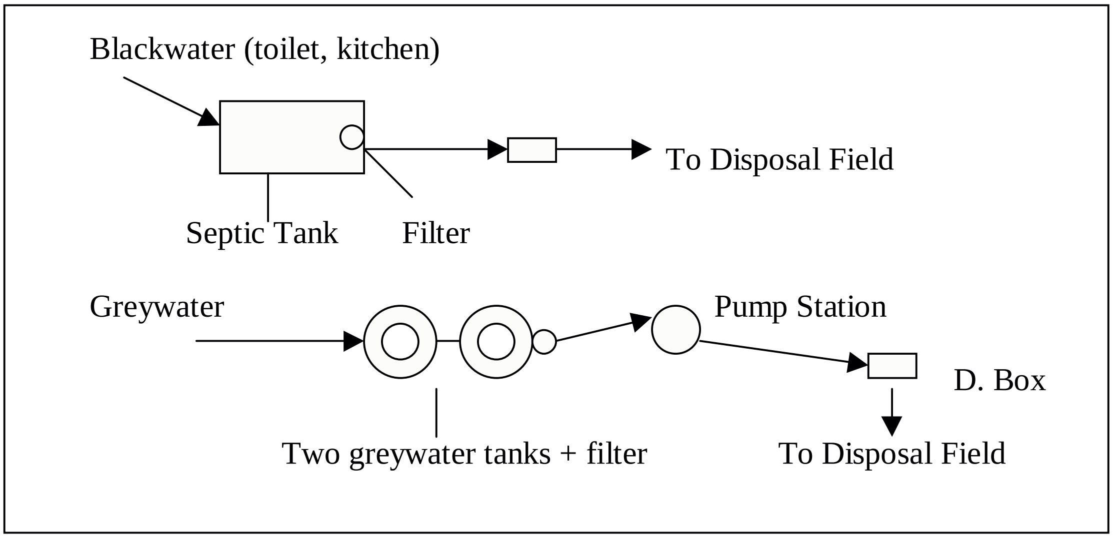


Figure 4. Outline of System D. Split blackwater/greywater.



Sampling methodology

System A was sampled from the outlet manifold, systems B, C and D from the Distribution Box. For B, C and D samples were collected at approximately 8 am for analysis on the same day at the Unitec laboratory. Samples from A were analysed on the same day at a commercial facility. Unitec samples were also independently assessed. For further information on systems A and B see Rambeck and Rimmer, (2004). Results are shown below.

Table 2. Results

		System A	System B	System C	System D
BOD_5	n	4	4	4	3
	Range	2 – 7.6	19 – 35	16 – 47	120 –160
	Mean	**5.4**	**25**	**30.2**	**135**
TSS	n	4	21	4	3
	Range	0.2 – 8	17 – 120	37 – 99	57 – 83
	Mean	**4.0**	**54.7**	**58.9**	**67**
FC	n	2	11	2	2
	Range	224 – 6.8 x 10^4	0 – 1.05 x 10^5	2 –2.08 x 10^3	8 – 10
	Mean	**4.1 x 10^4**	**9.5 x 10^3**	**2.04 x 10^3**	**9**

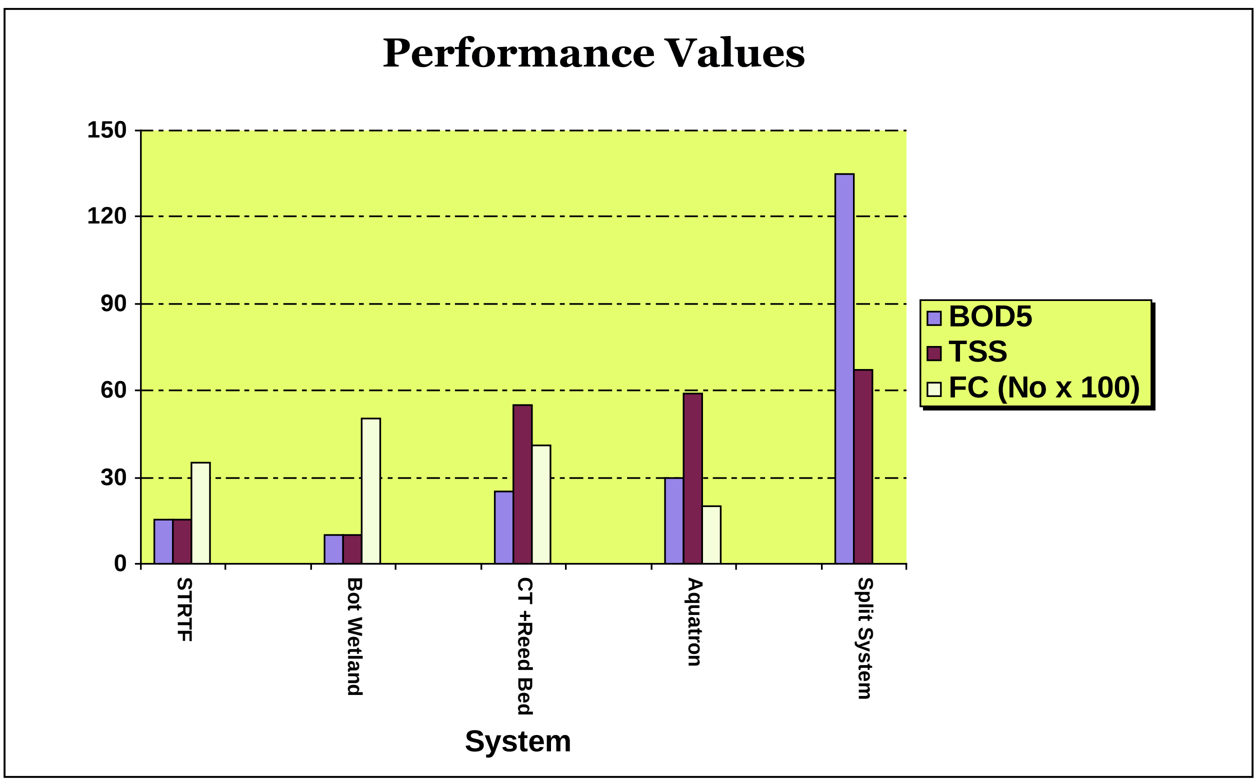
Water Quality Guidelines.

Regional authorities provide guidelines for acceptable performance of on-site systems. At present, these vary due to the type of system used and what local Councils will allow. Factors include section size (m^2), and overall environmental effects particularly with respect to sensitive areas. Guidelines for this paper are based on three sources: ARC TP 58, Draft third Edition, Ministry for the Environment 'Handbook on Sustainable Wastewater Management' and On-Site NewZ.
Three categories are chosen based on BOD_5, TSS and Faecal Coliform levels:

- 1. Excellent – with BOD_5 and TSS levels of 15 or less and FCs at 10^3 or less. This is considered advanced secondary treatment. These values for BOD_5 and TSS, are achieved by the septic tank recirculating textile filter combination (ST-RTF).
- 2. Very Good – with BOD_5 and TSS levels of 30 or less with FCs at 10^4 or less. Such levels are now recognised as the necessary standard for many systems and recognised as the criteria to be met for sensitive areas by some Regional Councils (see On-Site NewZ, 2004).
- 3. Good – BOD_5 and TSS of 70 with FCs at 10^5 or less.

Higher levels than category 3 while being acceptable in some circumstances in some localities, would now be generally considered as unacceptable.
While nutrient levels are important, categories are not suggested here, as insufficient performance information is available for the septic tank and recirculating textile filter (ST- RTF) example used for comparisons. Mean data values obtained from systems A, B, C and D are compared with the ST-RTF and shown in figure 5 below.

Figure 5. Water Quality Performance Measures



Discussion

System B values will more accurately reflect system performance, due to greater sample numbers. The smaller data set for the other systems reflects time and financial constraints. However, the data does provide an indication on the performance of such systems in New Zealand.

For BOD_5 and TSS, the botanical wetland (system A), gives excellent water quality with values lower than those for the septic tank with recirculating textile filter. The composting toilet/reed bed (B) and Aquatron system (C) achieve the category 2 rating of very good for BOD with TSS in the good range. System D BOD values do not fit the acceptable criteria chosen but TSS fall in the good range. However, it is important to note that systems C and D were sampled from the distribution box, prior to further filtration and therefore actual BOD and TSS values for effluent entering the disposal field would be lower.

For faecal coliforms all systems except D are placed in the very good range. The very low coliform levels found in D reflect the lack of faecal material in the system. Although values for BOD and TSS are relatively high, the low bacterial levels make such a system a good choice if there is a public health issue – provided the septic tank (blackwater component) operates well.

Sustainability

Traditionally, sustainability considerations have not been factored into design for on-site treatment systems, variations on the 'septic tank solution' with associated technological advances have been the norm accepted and supported by Councils and regulatory bodies. The other objective of this paper is to attempt to assess performance of the permitted system (ST –RTF) with alternative systems A –D, in light of a variety of sustainability criteria.

Rating system

A weighting system is used to assign values to both water quality data as well as five major sustainability categories. Weightings comprise 53% for water quality (18% BOD_5 & TSS, FCs 35%) and 47% for sustainability. The five sustainability categories are:

Energy and pollution from extraction to installation 8%, operational issues 20% (e.g. maintenance cost, energy in use, area for 'disposal'), local environment 10% (e.g. excavation and disposal of soils, and fill sites for septage), manufacture 7.5% (e.g. capital outlay) and choice 1.5% (do householders have one?). These categories are further divided into sub-categories and shown in Table 3.

Systems ST-RTF and A-D are given a score based on their water quality/public health performance and also in regard to the sustainability criteria. Scoring is kept simple with grades of 1, 2 and 3 corresponding with excellent, good and satisfactory for actual data values, and 1, 2, and 3 corresponding with low, moderate and high for relative values. These numbers are multiplied by the appropriate weighting factor to give a score. Scores are added to give a final total and rating. **Note that the lower the score the better the rating**, see Table 3.

Category	Class	Unit Value	ST & RTF	Score	System A	Score	System B	Score	System C	Score	System D	Score
Water Quality	BOD_5	0.9	1	0.9	1	0.9	1.5	1.35	2	1.8	3.5	3.15
	TSS	0.9	1	0.9	1	0.9	3	2.7	3	2.7	3	2.7
Public Health	Faecal Coli forms	3.5	1.5	5.25	2	7	2	7	2	7	1	3.5
Extraction – Installation	Energy Use	0.4	3	1.2	1.75	0.7	1.5	0.6	1.25	0.5	1.75	0.7
	Pollution – CO_2, $S0_2$	0.4	3	1.2	1.75	0.7	1.5	0.6	1.25	0.5	1.75	0.7
Operation	Maintenance	0.5	1.5	0.75	1.5	0.75	1.25	0.625	1.25	0.625	1.5	0.75
	Energy in use	0.2	2	0.4	1	0.2	0	0	0.5	0.1	1	0.2
	Energy for H_20 reuse	0.1	2	0.2	1	0.1	2	0.2	2.5	0.25	2	0.2
	Noise	0.1	1	0.1	1	0.1	0	0	0.5	0.05	1	0.1
	Odour/pests	0.2	1	0.2	1.5	0.3	2	0.4	2	0.4	1.5	0.3
	Land Area	0.2	1.5	0.3	1.5	0.3	1.5	0.3	1.25	0.25	2	0.4
	Intermittent use	0.4	1	0.4	1	0.4	2	0.8	3	1.2	2	0.8
	Flush & Forget'	0.3	3	0.9	1.5	0.45	1	0.3	1	0.3	1.5	0.45
Manufacture	Complexity	0.15	3	0.45	1.5	0.225	1	0.15	1	0.15	1.5	0.225
	Cost	0.6	3	1.8	2	1.2	1	0.6	1	0.6	1	0.6
Local Environment	Septage	0.5	3	1.5	3	1.5	1	0.5	1	0.5	3	1.5
	Excavation/fill	0.5	3	1.5	2.5	1.25	1	0.5	1	0.5	2.5	1.25
Choice Factor	Yes = 1, No = 0	0.15	1	0.15	0	0	0	0	0	0	0	0
	Final Score		**18.1**		**16.98**		**16.63**		**17.43**		**17.53**	
	Rating		★		★★★★		★★★★★		★★★		★★	

Table 3. System Rating using Performance and Sustainability Data

<u>Actual (numerical) Values</u>: Excellent = 1, Good = 2, Satisfactory = 3

<u>Relative Values</u>: Low = 1, Moderate = 2, High = 3

Discussion

Table 3 indicates that when sustainability measures are factored into choice of on-site waste/used water systems, all of the alternative systems achieve lower scores than the septic tank and recirculating textile filter. However, the range of values is low and as stated previously the weightings are subjective being based on the author's current knowledge and practical experience of such systems. Overall, the dry composting toilet, greywater tank and reed bed combination is rated the best, followed by the botanical wetland system (which would rate better if it did not utilise a pump). The latter gives the best results where water quality parameters are the main focus, followed by the septic tank/textile filter combination.

Conclusion

This paper is an attempt to raise awareness of performance of alternative on-site treatment systems for domestic waste and used water. The author believes such systems need much greater recognition as genuine options available to those householders who want them. They are simple, effective systems that use technology appropriately to better achieve sustainability goals.

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