PERFORMANCE OF SEPTIC TANK OUTLET FILTERS

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ABSTRACT

The decision of householders to install, or the need for authorities to legislate for the compulsory use of septic tank outlet filters, is made difficult by a lack of performance data. However, the growing body of evidence from the USA and New Zealand of the merits of septic tank outlet filters, the increasing number of available filters and the increasing interest in them as a means of protecting downstream components of wastewater treatment systems, give rise to the need to remedy this lack. Reductions of biochemical oxygen demand (BOD) and total suspended solids (TSS) are critically important measures of the benefits of wastewater treatment components.

This paper updates and extends the paper on septic tank outlet filters published in the Proceedings of Onsite '05, to take account of a number of new filters that have become available. It also reports the short-term treatment performance of a range of five different filters under test conditions, in terms of TSS and BOD reductions.

Outlet filter performance is of particular interest in the light of a recent decision by the AS/NZS committee reviewing the Standard AS/NZS1546, not to require the compulsory fitting of septic tank outlet filters.

Keywords: BOD, performance, septic tank outlet filter, TSS

1 FILTER UPDATE

Since the last review (Stafford and Whitehead, 2005) more filter designs have become available on the Australian and New Zealand market. Those reviewed below represent interesting and contrasting approaches to this aspect of wastewater treatment.

1.1 Bowco Industries EF-235 Filter

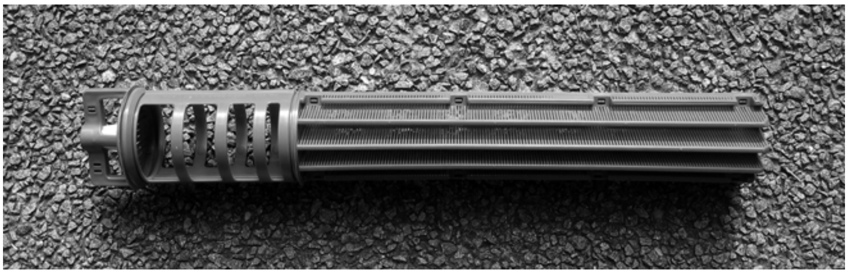

Figure 1. Bowco industries EF-235 Filter.

The EF-235 (Figure 1) is very similar to the Zoeller WW reviewed previously, but without the complexity of an outer sleeve at the outflow. As with the Zoeller, the WW plan form is employed to maximise the filtration area, however, the outflow is a simple ringed structure that permits operation at any angle of rotation thus minimising the risks of improper installation. The plastic is also softer and more flexible. Collars located immediately above and below the outflow hold the filter in place in the outlet tee, whether in a new installation or a retrofit. Although a basic handle is integral with the top of the filter, a threaded insert allows for the fitting of an extended handle. Bowco make few claims for their filter, simply stating that by filtering through the 1/16 inch slots, suspended solids are retained in the tank and the life of drain fields is dramatically increased. It is also claimed that cleaning of the filter should only be required when tanks are pumped out.

1.2 SIM/TECH STF-110 Bristle Filter

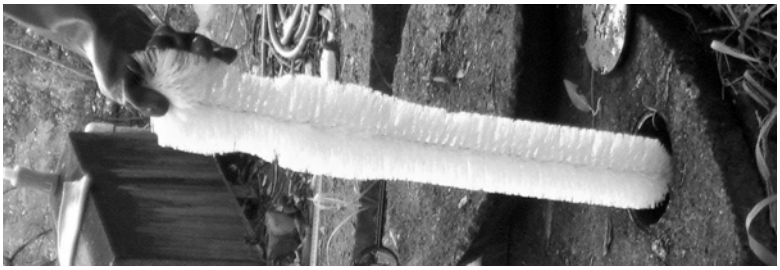

Figure 2. SIM/TECH STF-110 Bristle Filter.

While outlet filters fall into a limited number of categories, most being based on mesh or slotted screens, the SIM/TECH STF-110 Bristle Filter (Figure 2) is constructed like an oversized bottlebrush. The filaments of the filter are held in a twisted wire spine in a spiralling pattern. In plan this results in a radial geometry with the greatest spacing of the filaments at their outer tips. This is the point at which the largest gross solid could pass and thus defines the performance characteristics of the filter. Longitudinally, the filter is profiled to ensure it is firmly held in the outlet tee while at the same time ensuring an open structure at the outflow. The individual filaments are rough and angular in cross section. This may provide sites for biofilm development or hasten clogging. Although designed to be disposable, cleaning and reuse might be viable.

The manufacturers of the bristle filter offer a substantial amount of technical and dimensional detail including a third party verification of the various specifications and some aspects of performance relating to typical particulates found in septic tank effluent, but not BOD or TSS (A Lewis, pers. comm.).

1.3 Counterflow Column

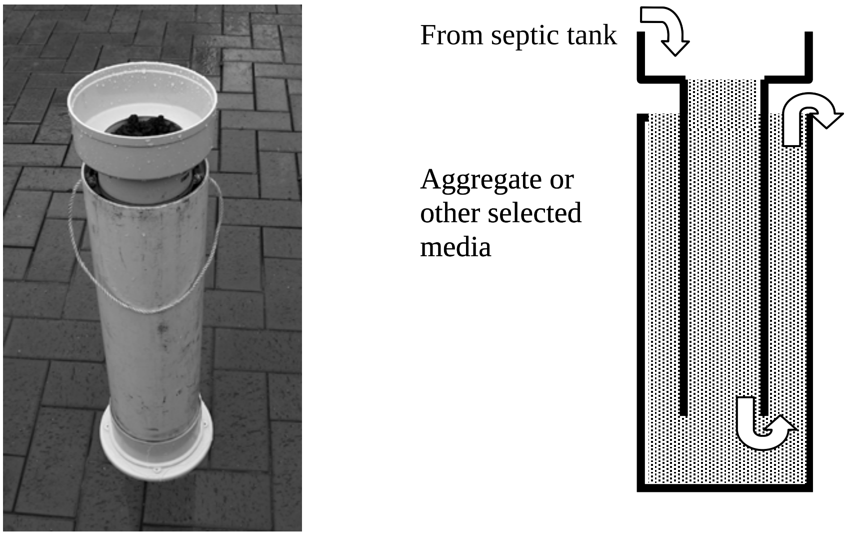

Figure 3. Counterflow Column.

The Counterflow Column, designed by Tim Woods, is a simple, robust concept that has been placed in the public domain; it can be easily constructed and maintained by system owners or plumbers. The design departs from the normal arrangement by placing the filter downstream of the septic tank outlet rather than in it. By varying the filter media, enhanced BOD and TSS removal may be achieved as well as possible nutrient reductions. As it needs to be located in a chamber downstream of the septic tank, the filter is particularly well suited to installation in dosing systems.

2 SURFACE AREA MEASUREMENT

The surface areas tabulated in the previous review (Stafford and Whitehead 2005) were calculated manually using a micrometer to measure each component. The objective was to determine the actual wetted surface area but due to the construction of the mesh screens in particular, the results were not fully objective as a degree of estimation was required. For this review, a better method of calculating surface area was sought. In particular the BET (Brunauer *et al*. 1938) and Langmuir (Blodgett and Langmuir 1937) models were considered. Both measure exposed surface areas at a molecular scale and would have provided very accurate measurements. However, the lack of laboratories willing and able to undertake the measurements and the uncertainty of any direct relationship between surface area and filter performance emerging from the field tests led to the employment of a simple volumetric measurement as a guide to the physical characteristics of the filters. Surface area and volumes of various outlet filters are listed in Table 1.

Table 1. Surface area and volume.

Manufacturer / Filter	Surface area cm^2 (Note 1)	Volume L (Note 2)	Notes:
Bio Microbics SaniTEE 1.6 mm		1.04	**1** total wetted surface area from bottom of filter to 10mm above the outlet invert with filter installed to manufacturers recommendation. In the Onsite '05 paper 'Septic Tank Outlet Filters' (Stafford and Whitehead, 2005), a typographic error resulted in the surface area units being stated in mm^2, when they should have been stated in cm^2. **2** volume is given for that part of the wetted filter as for note 1 above.
Bio Microbics SaniTEE 3.15 mm		1.01	
e-cogent EcoTube	5889	0.4	
Everhard XtraTreat	6286	0.32	
OSI FTi Biotube	4017	0.22	
OSI FT Biotube		0.69	
Taylex	2110	0.19	
Zoeller WW	4876	0.3	
Bowco Industries EF-235		0.42	
SIM/TECH STF-110	12,758	0.08	

3 FLOW RESISTANCE

The flow rate measurements for two filters, additional to those recorded in the Onsite '05 review (Stafford and Whitehead 2005), are listed in Table 2.

Table 2. Indicative flow resistance of outlet filters.

Manufacturer/Filter	mm head at 5 Lm^{-1}	mm head at 15 Lm^{-1}	mm head at 25 Lm^{-1}
Bowco Industries EF-235	<3	<3	6
SIM/TECH STF-110	<3	<3	5

4 PERFORMANCE TESTING

Outlet filters were placed in two mature septic systems, one approximately 20 years old in Cardiff Heights, NSW and the other over four years old in Martinsville, NSW. The Counterflow Column filter was tested in a test bed set up in a holding tank which collected primary treated effluent from an approximately 60 year old, but recently pumped septic tank and vertical grease trap at a precast concrete factory in Rockhampton, Queensland. Effluent samples were taken at approximately weekly intervals for a period of between five and seven weeks for each domestic system, pre and post filter, and on four occasions, each using a different filter medium, at the commercial installation. All samples were analysed for BOD and TSS at NATA laboratories.

4.1 Treatment Systems

The treatment system in Cardiff Heights is in a semi rural area; that at Martinsville is in a rural location. The number of occupants, household practices, the nature of the water supply and the hydraulic load on the septic tanks are shown in Table 3. The Everhard Xtra Treat and Sim/Tech STF-

100 Bristle Filters were tested at Cardiff Heights and the Taylex and Zoeller WW filters were tested at Martinsville.

Table 3. Test conditions.

Cardiff Heights	
no. of occupants	7 persons
diet	non-vegetarian
eco-consciousness	modest quantities of a regular selection of household cleaning products used
water	town supply
maintenance	no regular maintenance, > 7 years since septic tank pumped
hydraulic load	up to 650 L/day
septic tank	3500 L concrete septic tank for primary treatment followed by 3500 L concrete pump chamber with pump to sewer
Martinsville	
no. of occupants	2 (occasionally 4) persons
diet	vegetarian, low fat
eco-consciousness	washing powder/detergent use minimized, zero phosphate or nitrate powders chosen
maintenance	on site treatment system carefully monitored and maintained
water	tank supply; first flush units fitted
hydraulic load	up to 350 L/day
septic tank	3000 L baffled septic tank with secondary treatment by siphon dosed single pass sand filter and shallow subsurface drip irrigation
Rockhampton	
no. of occupants	approximately 10, daytime workforce only
diet	workforce mess room and kitchen only
eco-consciousness	high phosphorus soap used, oil and grease cleaning and tools washed
maintenance	septic tank recently pumped out
water	90+% town water supplemented by some tank and creek supply
hydraulic load	approximately 800 L/day
septic tank	filter receives primary treated effluent from a 1600 L septic tank and 800 L grease trap at a precast concrete factory

The Counterflow Column filter was tested using four different types of medium, fine washed zeolite (<2 mm), coarse zeolite (15-20 mm), coarse scoria (15-20 mm) and a mixture of coarse zeolite and coarse scoria (15-20 mm). In each test the new media was allowed to "settle" for two days in the system before testing.

4.2 Sample collection

Pre-filter sampling from both domestic septic tanks was from a position adjacent to the bottom of the outlet tee. This was achieved by inserting a plugged tube until its opening was at the correct level then opening the plug; once filled the opening was again plugged and the sample removed and decanted. Post-filter sampling from both septic tanks was facilitated by existing collection wells located immediately downstream of the septic tank outlets. The Cardiff Heights collection tank was fitted with a 2 L bucket under the outlet. Once the bucket was filled, any effluent discharged from the septic tank circulated through the bucket in turbulent conditions and spilled over into the main collection well. Between effluent discharges from the septic tank, the sample in the bucket remained static with the possibility of settlement. Sampling was generally undertaken after recent flows through the system, so the sample collected for analysis would represent a freshly filtered sample which had not been standing for any great length of time. Samples were taken from the bucket at weekly intervals. At Martinsville, dynamic sampling was employed. A tap, upstream of the septic tank, was run to cause sufficient effluent to be discharged from the tank and a sample taken directly at the outlet, also at weekly intervals.

4.3 Results

Pre-test BOD and TSS ranges and means for the three systems at which testing was undertaken is presented in Table 4. These figures reflect the domestic nature of the effluent load at the Cardiff Heights and Martinsville test sites. BOD ranges and means are similar at these two sites. The TSS range at the Cardiff Heights site reflects in part the older system with a greater sludge accumulation in the primary tank, the higher hydraulic load and a greater frequency of surge loads from baths, showers, washing machine and dishwasher. The Martinsville site has a significantly smaller range and lower mean TSS. This reflects the newer system, smaller hydraulic load and contrasting household practices which minimize contaminant discharge to the system. The non-domestic nature of the Rockhampton test site shows in significantly lower mean BOD and relatively low mean TSS despite the hydraulic loads being relatively high.

Table 4. Pre-test BOD and TSS ranges and means.

System	BOD mg/L		TSS mg/L	
	Range	Mean	Range	Mean
Cardiff Heights	154-377	241	90-584	282
Martinsville	129-408	230	62-112	83
Rockhampton		68		125

Figures 4, 5, 6 and 7 present pre- and post-filter BOD and TSS data for the four outlet filters tested in the domestic systems. Figure 8 shows comparable results for the Counterflow Column.

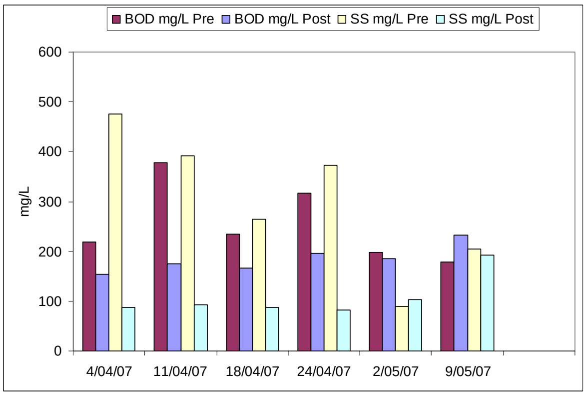

Figure 4. Everhard Xtra Treat Filter.

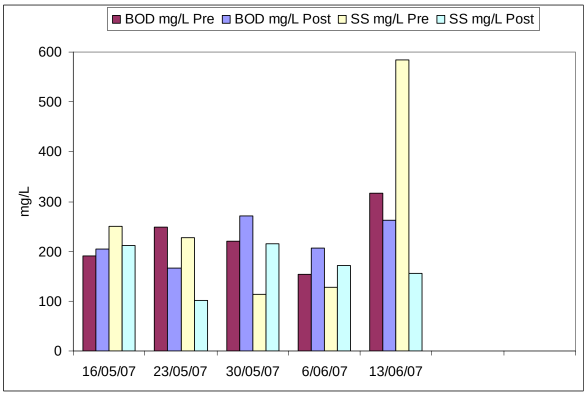

Figure 5. SIM/TECH STF-110 Bristle Filter.

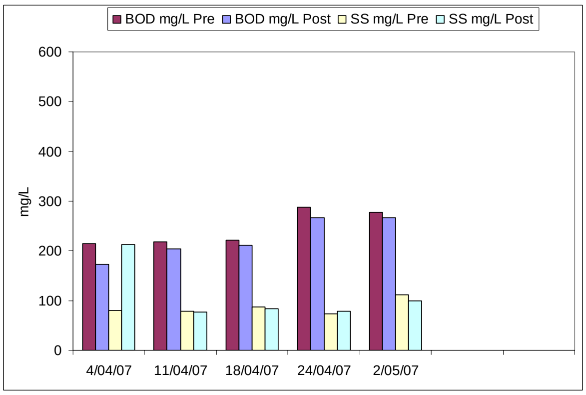

Figure 6. Taylex Filter.

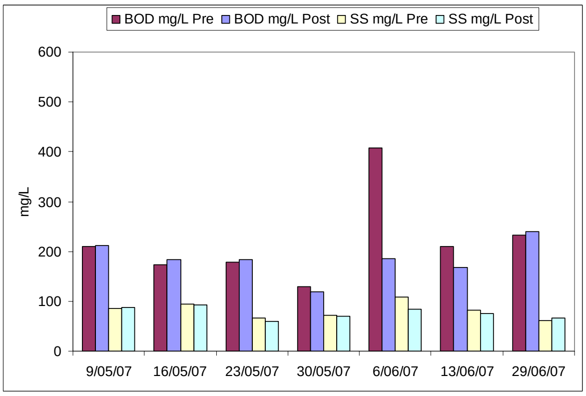

Figure 7. Zoeller WW Filter.

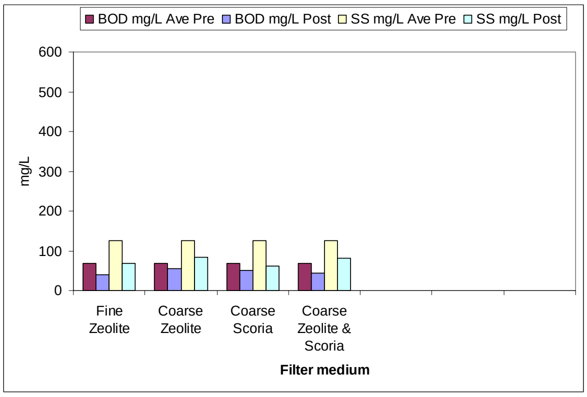

Figure 8. Counterflow Column.

Table 5 displays the wet weight of the drained domestic outlet filters on the days of sampling.

Table 5. Wet weight of the drained filters.

Week	Filter			
	Everhard Xtra Treat Filter g	SIM/TECH STF-110 Bristle Filter g	Taylex Filter g	Zoeller WW Filter g
Pre-test	385	300	360	350
1	395	387	395	350
2	400	407	360	360
3	395	464	360	360
4	410	495	360	360
5	407	515	360	360
6	430			360
7				360

4.4 Everhard Xtra Treat Filter

Over the six week testing period BOD and TSS reductions were variable. In the early weeks of testing TSS reductions were substantial, proportionally rather more than BOD reductions and they averaged some 75%, however, in the fifth and sixth weeks performance reduced significantly. In weeks five and six TSS and BOD were respectively exported. These weeks followed the first appearance of significant biofilm development on the filter surface and in week five the weight of the filter and biofilm had fallen from week four. By week six the biofilm growth rate had increased again. It is possible that BOD is exported once biofilm growth commences and accumulates on the filter surface.

4.5 SIM/TECH STF-110 Bristle Filter

In three of the five weeks of testing BOD increased post-filter and in two of the five weeks TSS increased post-filter, though these weeks did not wholly concur. Over the test period this filter accumulated a substantial 215 g of material amongst the bristles. This would suggest that the filter might need cleaning or replacement at relatively frequent intervals. Manufacturer's information suggests that the filters should last for twelve months and a suitable filter shaped plastic bag is provided for disposal of the used filter. In the final week of testing the filter was particularly effective in reducing TSS which had more than doubled on previous weeks to almost 600 mg/L. This increase followed the well documented 8 June storm which affected the Hunter Region. The property at which the filter was under test was without power for five days and consequently hydraulic loads were significantly reduced as the washing machine and dishwasher were not used, hot water for showers was limited and toilet flushing was reduced to a minimum. Consequently both BOD and TSS of the effluent increased significantly, yet the filter managed a commendable 77% reduction in TSS.

4.6 Taylex Filter

Over five weeks of testing the filter consistently maintained slight but barely significant reductions in BOD. For the most part TSS reductions were similarly insignificant. In the first week of testing, post-filter TSS was significantly higher than pre-filter TSS. This result flagged a problem with sampling, whereby the post-filter sample was remaining static prior to sampling and TSS appeared to be accumulating in the sample chamber. This was corrected for subsequent weeks and a more effective dynamic sampling procedure put in place. With the exception of the first week, when some solid matter was caught in the filter, the filter did not gain weight as biofilm development on the filter was negligible. This might reflect the nature of the Martinsville septic tank which experiences relatively light loads and has not developed a crust in the four years since commissioning, yet otherwise performs very well and does not generate odours.

4.7 Zoeller WW Filter

For this filter, seven samples were tested over an eight-week period. On more than half of the sampling occasions, post-filter BOD values exceed pre-filter values, albeit on all of these occasions by a small margin. It was not until the fourth week of testing that a BOD reduction was noted and this coincided with an approximate 100% unexplained increase in influent BOD over previous weeks. This BOD removal continued for one further week before returning to overall export of BOD. TSS reductions were modest throughout the whole period of testing. This filter has a small dimension opening of 1.25 mm (Stafford and Whitehead, 2005), the smallest of all filters investigated as part of this program. It would seem, however, that this reduced screen opening size does not impact significantly upon TSS removal for this relatively low TSS septic system. Again this filter, tested in the lightly loaded Martinsville septic system developed very little biofilm.

4.8 Counterflow Column

Figure 8 presents mean pre- and individual post-filter BOD and TSS data for the four filter media tested in the Counterflow Column system. Mean data for pre-filter tests of BOD and TSS is presented, as one individual pre-filter sample result was considered not valid.

This innovative outlet filter differs in style from the other more conventional domestic outlet filters tested and testing was undertaken on one occasion only for each of four different filter medium options. The fine zeolite, whilst effective in removing both BOD and TSS, was too fine and caused clogging of the filter and an unacceptably low flow rate. Influent BOD to the Counterflow Column was much lower than to the filters tested in the two domestic systems. This limited data suggests that zeolite is marginally more effective in BOD reduction, whilst scoria is similarly so for TSS and a combination of the two media maintained a balance in the reduction of both contaminants.

5 CONCLUSIONS

Testing of four outlet filters for periods of between five and eight weeks demonstrated very variable performance, both of individual filters and between filters. The filters tested represent a modest sample of the outlet filters available on the Australasian market, but represent a range of filter styles and modes of construction.

The performance of the two filters tested at the Martinsville household with a low hydraulic load and low pre-filter BOD and TSS made minimal to insignificant difference to the quality of post-filter effluent, other than on one occasion where BOD was abnormally high and more than 50% reduction was achieved. These filters developed very little biofilm over the test period.

The performance of the two filters tested at the Cardiff Heights household with an older septic system, a higher hydraulic load and more frequent surges reaching the septic tank was again variable, with some substantial (>50%) reductions in BOD and TSS achieved, for the most part where BOD and TSS were relatively high, however, on other occasions, both post-filter BOD and TSS was found to be higher than the corresponding pre-filter values. There was evidence in the case of both filters to suggest that, once biofilm development commenced and gross solids build-up on the filter increased, even after a relatively short time, both BOD and TSS can be exported and post-filter effluent quality can be adversely affected.

Where BOD and TSS levels in septic tanks are elevated, for example by atypical wastewater generation events or surges, outlet filters appear to be most effective, whilst for effluent with lower levels of BOD and TSS their effectiveness is less significant. Outlet filters clearly can prevent the passage of gross solids, thereby protecting downstream pumps and siphons in on-site systems but this short-term study does not present any evidence to suggest that outlet filters can reliably and consistently remove BOD or TSS. There is clearly a need to thoroughly examine the performance of the wide range of outlet filters available on the market and to undertake detailed long term studies of their performance in a range of on-site systems of different ages, sizes and loading and maintenance characteristics.

Given that the AS/NZS committee reviewing the Standard AS/NZS1546 have recently deferred a decision to require the fitting of outlet filters in septic systems (without the benefit of the results of this study) and that the Standard is now subject to periodic review every five years, there is both a great opportunity and a pressing need for such research to be undertaken in the next few years to enable an informed decision to be made on the basis of some sound science in time for the next review of AS/NZS 1546.

6 ACKNOWLEDGEMENTS

The Counterflow Column trials and monitoring in Rockhampton was undertaken courtesy of Ben Kele.

7 REFERENCES

Blodgett, K. B. & Langmuir, I. (1937). Built-Up Films of Barium Stearate and Their Optical Properties, Phys. Rev. 51. 11. pp. 964 – 982. American Physical Society.

Brunauer, S., Emmett, P. H. & Teller, E. (1938). *J. Am. Chem. Soc.*, **60**, 309.

Stafford, D. J. & Whitehead, J. H., (2005) *Septic Tank Outlet Filters*, In Patterson, R. A. & Jones, M. J., (Eds.) Proceedings of On-site ‘05 Performance Assessment of On-site Systems: Regulation, Operation and Monitoring. Lanfax Laboratories, Armidale.