PEAT TREATMENT OF SEPTIC TANK EFFLUENT

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Abstract

Noxious products in septic tank effluent prevent its direct application to landscaped areas around the home, except through subsurface soil systems. Reduction in these components can be achieved through better treatment, often with significantly higher energy, chemical and maintenance inputs. The use of low energy treatment, by percolating effluent through a peat bed, has been explored as a means of reducing suspended solids, nitrogen and phosphorus products and faecal coliforms.

Following a series of laboratory experiments to evaluate loading rates, a peat bed of 18 m^2 was constructed as part of the on-site wastewater treatment system connected to a typical household. Effluent from an all-waste, single chambered septic tank flowed to a distribution system above the surface of the peat. Effluent passing through the peat was collected in a collection well, from where it was pumped to irrigation areas.

Over a period of 13 years, significant reductions in suspended solids, biochemical oxygen demand, nitrogen, phosphorus and faecal coliforms have been achieved with almost no maintenance of the simple system. It is concluded that significant improvement in the quality of effluent available for surface or subsurface irrigation will reduce environmental impacts and allow on-site systems to operate on small parcels of land.

Keywords

faecal coliforms, peat, phosphorus sorption, septic tank effluent, wastewater

1 Introduction

1.1 Septic tank effluent

Septic tank effluent (STE) is a noxious liquor of organic and inorganic residues, present as soluble and insoluble materials in a liquid matrix. It is usually characterised in terms of those constituents that give rise to pollution; nitrogen (ammonia, nitrite and nitrate), phosphorus, total suspended solids (TSS), biochemical oxygen demand (BOD_5) and faecal coliforms (FC). An analysis of the complex array of putrefying organic compounds is generally irrelevant for traditional drainfields because they decompose in the soil surrounding the trench, away from human contact.

Where the effluent is to be disposed of by surface application, particularly on a residential allotment, the removal of odour and bacterial contamination is of major concern. Chlorination, to disinfect the effluent, is commonly achieved by a dosing system with sodium hypochlorite tablets. However, as there are no published data which address the impact of chlorinated effluent on soil biology, the practice of effluent chlorination may be detrimental to beneficial soil microorganisms. From other microbiological studies, it could be suspected that soil microfauna and flora are adversely affected by the minimum residual chlorine level of 0.5 mg L^{-1} that is required at the time of effluent application (NSW Health Department, 1993; NSW Recycled Water Coordination Committee, 1993; DLG, 1998).

Treatment of STE before disposal to the environment is desirable. As a consequence, aerated wastewater treatment systems (AWTS), multi-chambered tanks which provide primary (sedimentation) and secondary (aeration) treatment of the domestic wastewater and final chlorination, have been developed to provide that additional treatment prior to discharge of effluent for surface irrigation. As an alternative treatment system, a peat bed was developed as a low energy STE pretreatment medium. Prior to that study (Patterson, 1994), there had been no research or documentation on the use of peat beds in Australia for the treatment of domestic STE.

1.2 Peat as pre-treatment medium

Research in the United States has shown peat to be effective in removing phenol, odorous gases, textile dyes, alkyl benzene sulphonate (ABS) found in detergents, and heavy metals from a variety of municipal and industrial wastes. The first use of peat for domestic wastewater treatment was documented by Brooks (1980) with subsequent laboratory studies by Rock *et al.*(1982) and field studies by Brooks *et al.* (1984) and Rock *et al.* (1984a). Loading rates of STE into the peat bed varied from 15 to 81 mm per day, and treatment efficiency varied according to packed bulk density of the peat bed, sphagnum variety and loading rate. Removal of coliforms and reduction in nitrate and phosphate levels were of the order of 60-90%.

Brooks *et al.* (1984) suggested that the naturally occurring bactericidal fungi, the phenolic properties of peat and its acid aerobic environment are responsible for the almost total removal of total and faecal coliforms. Less than 1000 thermotolerant (faecal) colony forming units (CCU) per 100 mL are required to meet Australian guidelines for agricultural waters (ANZECC, 1992). The guidelines for urban and residential re-use recommend 2.5 cfu/100 mL (NSW Recycled Water Coordination Committee, 1993). Brooks *et al.* (1984) measured a range of 0-70 cfu/100 mL in treated effluent, after six months of operation, at a loading of 15 mm per day. The experiment by Rock *et al.* (1984b) showed that FC levels could occasionally exceed 100 cfu/100 mL.

1.3 Peat availability

The primary use of peat in Australia has been for the commercial horticultural industry, where it is used as a potting medium, either wholly or as a proportion of potting mixtures. It is valued because of its reliable quality, sterility, high water holding capacity, air filled porosity and high cation exchange capacity. While the peat used in the original trials by Patterson (1994) is no longer available, an alternative source of reed-sedge (black) peat has been commercially developed in Victoria (Pacific Agriculture, *pers. comm*.). A range of sphagnum moss peats imported from Germany, New Zealand and Russia is available. A peat bed using "Warrior", a New Zealand sphagnum moss peat has also been constructed and is performing well.

1.4 Laboratory evaluation of peat for pre-treatment of STE

Laboratory experiments were developed to evaluate the potential for two locally available peats and an inert porous material to treat STE prior to soil disposal. The peats used here were a New Zealand sphagnum moss peat ("Warrior") and Amgrow's Australian reed-sedge peat. The inert material was Growool (Trademark-Bradford Insulation), a bonded form of crude natural glass fibres, non-biodegradable, with a cation exchange capacity near zero.

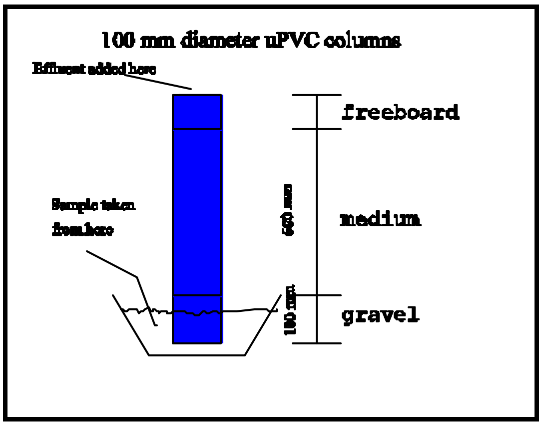

Figure 1. Experimental columns

The 750 mm tall columns of 100 mm diameter uPVC (unplasticised material) sewer pipe were packed with a base layer of 100 mm of 15-30 mm gravel (crushed acid washed basalt) and 600 mm of the respective peat or Growool, as shown in Fig.1.

There were no significant differences between the columns when compared to more than 2 x 10^5 cfu/100 mL coliforms in the applied STE.

The results of the laboratory experiment suggest that the peat is an effective medium for the pre-treatment of STE to reduce FC, suspended solids, odour and phosphorus. Growool also was successful in removing those contaminants, but at a reduced level. It is considered that the peat and Growool provide a mechanism for filtering the larger solids from the STE and also a substrate upon which the microbial population reside. Microbial populations in the peat consume the organic materials, filtered out from the added STE as part of their metabolism, producing cleaner effluent.

The mean faecal coliform colony counts over the first 16 weeks were less than 2000 cfu/100 mL from a population in the untreated effluent of more than 200 000 cfu/100 mL; that is, a reduction of more than 99%

was achieved. The lower dosing rate of 41 mm resulted in a coliform count of about 1000 cfu/100 mL, compared with 2400 cfu/100 mL for the 82 mm rate. However, this difference is insignificant when compared to the coliforms found in the untreated STE. These levels compare favourably with the recommended levels of 1000 cfu/100 mL for agricultural use of wastewater, but not with the <1 cfu/100 mL for domestic use. The reduction achieved makes it much easier to bring the coliform count down to the recommended levels by disinfection, such as chlorination.

2 Field Evaluation of a Peat Bed

2.1 Peat bed design criteria

As a result of the satisfactory performance of the laboratory test, a full size domestic pre-treatment system was constructed to treat 600-1000 L of domestic STE daily.

The requirements of the design and operation of the peat pre-treatment bed were that:

- (a) it should be maintenance free, with little concern given to household loadings to the septic tank;
- (b) it should operate satisfactorily for more than five years;
- (c) the treated effluent should be able to be used for spray irrigation;
- (d) the system should operate with minimum consumption of electrical energy; and
- (e) no disinfection of the treated effluent would be provided.

2.2 Peat bed construction

The peat bed was located to facilitate gravity flow from the existing septic tank to the bed. The soil type was a duplex grey-brown podzolic, with a clay loam topsoil overlying a medium clay. A bed of dimensions 6 x 3 x 0.6 m was excavated by machine and finished by hand. As the clay subsoil was slowly permeable (Ksat < 5 mm/day), no lining was installed. The 1600 L concrete collecting well was installed so that the inlet to the tank was below the floor of the bed. Figures 2 and 3 indicate the relative cross-sections of the peat bed.

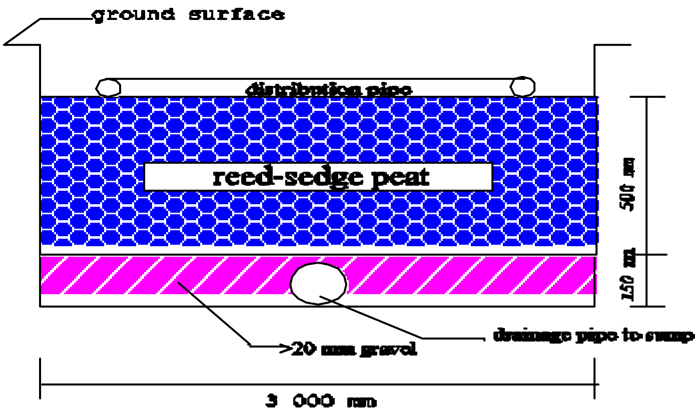

Figure 2. Cross section of peat bed

A slotted uPVC pipe was placed with gravel (< 20 mm) around it to form a 150 mm thick drainage bed on the floor of the bed. This layer was covered with 4800 kg reed-sedge peat (2520 kg oven-dry weight) to a depth of 500 mm, raked and tramped to a bulk density of approximately 230 kg m^{-3}, twice the density used in the experimental columns. The higher bulk density was chosen to reduce the loss of depth as the peat consolidated over time.

Eight distribution pipes, with 8 mm holes drilled at 300 mm intervals, were arranged above the peat bed, as a closed network from a single inflow manifold, as shown in Fig.2. A fall of 1:500 to the corner diagonally opposite the inflow was provided. The effluent gravity fed through the system, dripped from the drilled holes and drained through the peat. It collected in the slotted PVC pipe and flowed to the collection well. Initially, the sump was fitted with a manually operated pump so that accurate volumetric measurements of the effluent could be made before it was irrigated. Three years after monitoring commenced, the system was fitted with a submersible pump, equipped with a float switch, to pump the effluent automatically to the sprinkler system.

2.3 Peat bed loading

The effluent loading of the peat bed was designed for a household of seven persons producing between 600 and 1000 L of STE daily. This rate of water usage equates to a surface application of effluent onto the peat bed of 34-55 mm per day, less than the design rate of 82 mm per day. The system operated at 81 mm per day over a short term when the number of laterals operating in the distribution system was reduced from 8 to 5 due to clogging of the distribution system. Rainwater was not excluded from the bed other than by preventing overland flows entering the system. Rainwater entering the bed was expected to provide some cation and nutrient flushing from the peat. Evaporative losses from the peat bed were not incorporated into the design.

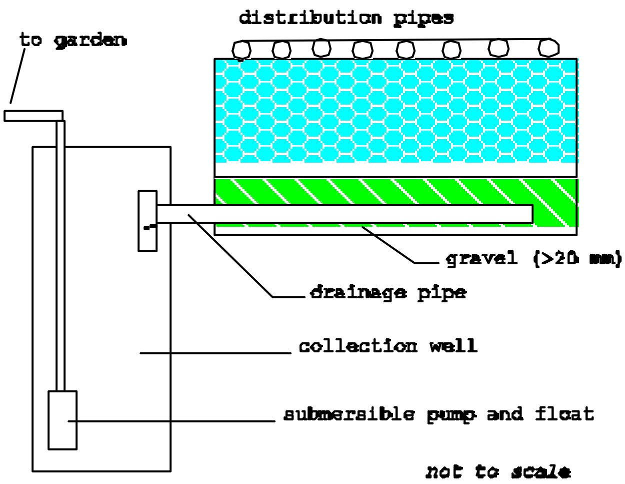

Figure 3. Side elevation of peat bed

2.4 Installation costs

The treatment system was designed so that its cost would be similar to that involved in replacing a failed traditional drainfield. The system utilised standard plumbing fittings and micro-spray irrigation. Based upon 1999 costs, the peat bed could be installed onto an existing septic tank system for about $3500, with an additional $500 for a simple irrigation system. Other than for the small submersible pump, the system is energy neutral with minimum maintenance.

3 Monitoring the system

3.1 Initial operation

The system commenced operation in October 1986 and continues at time of writing (May 1999). Until May 1994, monthly measurements were made of pH, EC, base cations, nitrate nitrogen, phosphorus (as orthophosphate), BOD_5 and FC using Standard Methods (APHA, 1985). Other than re-levelling the distribution system because of peat subsidence, less than one hour's maintenance was performed on the peat bed over that period. The grass and weeds were allowed to invade the surface of the bed as they provided a means for removing nutrients and enhancing the aesthetics of the bed. On rare occasions, the grass was cut and removed to discourage domestic stock from pushing on the small fence surrounding the peat bed.

The solids carry-over from the septic tank caused blockages in the 8 mm holes drilled in the distribution line. Blocking was due to the formation of a black slime of polysaccharides, which contributes to the clogging layer in a conventional drainfield. Even though the septic tank was pumped out prior to commencement of the field trial, the pipes clogged within three months. A trap was constructed in the line to remove the gelatinous substance before it could reach the distribution system. Once this trap was installed, there were no further blockages in the distribution system. The trap was not cleaned out over the intervening period because the slime decomposes and moves away with the effluent. Four years after the peat bed was constructed the septic tank was cleaned out to maintain a STE with low carry-over of solids. Weeds growing on the peat bed were kept under control by spraying with glyphosate.

A clogging layer had formed on the surface of the peat by the fifth year and was restricting the infiltration of both effluent and rainwater into the peat. As a result water was ponding in the far corner of the bed and slowing percolating through the peat over a number of days. The clogging layer was disturbed by raking away, allowed to dry and replaced on the surface. The prolific grass growth also provided some clogging but the benefits of the vegetation to increase removal of water and nutrients were observed to outweigh any disadvantages.

3.2 Continuing operation

The peat bed has continued in operation since 1986 and no further maintenance has been performed, other than routine reduction of weed growth by spraying with glyphosate. No monitoring was undertaken from May 1994 until March 1999 when three samples, taken at weekly intervals, were analysed and compared with STE samples, as shown in Table 1.

3.3 Maintenance Aspects

While no significant maintenance has taken place over the 13 years of continuous operation, there was a need to provide adequate fencing to prevent stock gaining access to the prolific vegetation growing on the bed. The subsidence of the system created problems for the even distribution of effluent over the surface of the peat bed and an alterative physical support is required for the distribution network, although this has not been completed for the present system.

No sludge has been removed from the collection well over the entire period of operation, although the septic tank was pumped out in 1991 and 1996. There has been no malfunction of the submersible pump since its installation in 1989 and no maintenance provided.

Effluent from the peat bed has been used for surface irrigation around the residence since trial irrigation areas were used as part of initial research (Patterson, 1994). Irrigation has been by both sprinkler and open pipe distribution around landscaped areas.

3.4 Chemical changes to effluent

The effluent flowing from the septic tank represents that of a typical household using rainwater inputs at conservative consumption rates of less than 150 litres per person per day (Lpd). Over time there has been deterioration in the treatment provided by the peat bed, not unexpected after 13 years without nutrient removal mechanisms. The non-continuous monitoring prevents the definition of the acceptable life of the peat bed with respect to phosphorus reduction, although for landscaping purposes, phosphorus is beneficial to increased plant growth where adequate water is available. While the continuing retention of total phosphorus (TP) by the peat bed can be partly attributed to the retention of solids, the through-flow of orthophosphate (soluble phosphorus) indicates that the peat is at its sorption limit.

The reduction in total suspended solids (TSS) carried over from the septic tank during peat treatment represents a significant removal of solids or up to 98% continuously over the 13 years. The benefits of such a reduction are that micro-irrigation equipment is less likely to suffer blockages, and soil pores around any dripper line will not be clogged with the solids. If it became necessary to disinfect the effluent, the clarity of the effluent is suitable for UV disinfection.

The FC reduction of the STE within the peat bed has continued to provide in excess of 99% disinfection, without the need for chlorination. During the first six months of operation FC counts remained under 200 cfu/100 mL; however, from then onwards the average counts averaged 700 cfu/100 mL during the next two years. The average summer FC count was lower than the winter count. By 1992, six years after operation, the FC count averaged 2300 for winter and 1100 for summer while the level for March-April 1999 was 3200 cfu/100 mL.

The removal of solids from the STE and aeration during treatment has reduced the BOD_5 of the final effluent. At no time during the first six years of operation was the BOD_5 recorded at more than 10 mg L^{-1} (median 6.5 mg L^{-1}, CV 15%). The BOD_5 of STE was not regularly monitored but levels over 400 mg L^{-1} were typical. During March-April 1999, BOD_5 levels of 423 mg L^{-1} for the STE and 24 mg L^{-1} for peat bed effluent were measured, a reduction of 94%.

Phosphorus levels within STE are determined not only by the diet of the household members, but also through the use of laundry products and household cleaners (Patterson, 1998). Phosphorus levels of the STE varied significantly over the period as the laundry products purchased for research were consumed within the household. The phosphorus capacity of the peat bed was exceeded sometime after 1994 and the bed is no longer a repository for phosphorus, other than the removal of TP load with solids retention.

Table 1. Comparison of STE to peat bed effluent over three periods during 13 years of operation.

		March-April 1987			April-May 1994			March-April 1999		
Component	Units	STE	Peat	change %	STE	Peat	change %	STE	Peat	change %
pH		7.20	5.50	-23.6	7.60	6.40	-15.8	7.64	7.41	-3.0
EC	dS m^{-1}	0.920	0.560	-39.1	0.750	0.580	-22.7	0.860	0.600	-30.2
Chloride	mg L^{-1}	46.5	42.0	-9.7	42.0	37.0	-11.9	40.6	38.4	-5.4
BOD_5	mg L^{-1}	352.0	6.5	-98.2	385.0	35.0	-90.9	423.0	24.0	-94.3
TS	mg L^{-1}	875	230	-73.7	780	320	-59.0	847	293	-65.4
TSS	mg L^{-1} #	482	15	-96.9	398	12	-97.0	510	10	-98.0
TDS	mg L^{-1}	420	260	-38.1	320	360	12.5	340	330	-2.9
Alkalinity	mg L^{-1} #	780	350	-55.1	650	320	-50.8	810	470	-42.0
Ortho-P	mg L^{-1}	11.4	8.2	-28.1	15.1	12.2	-19.2	10.1	10.7	6.0
TP	mg L^{-1}	16.4	8.2	-50.0	18.2	12.2	-33.0	14.5	10.7	-26.6
SO_4^{2-}-S	mg L^{-1}	16.5	8.6	-47.9	16.5	10.6	-35.8	12.5	11.2	-10.4
NH_4^+-N	mg L^{-1}	75.2	18.6	-75.3	45.6	15.2	-66.7	67.1	23.6	-64.8
NO_3^--N	mg L^{-1}	3.2	0.1	-96.9	2.6	0.1	-96.2	4.1	0.1	-97.6
TN	mg L^{-1}	76.1	20.1	-73.6	55.6	18.6	-66.5	85.2	26.1	-69.4
FC	cfu/100 mL	6×10^5	650	-99.9	9×10^5	1650	-99.8	9×10^5	3200	-99.6
SAR		3.6	2.9	-19.4	3.8	3.5	-7.9	3.52	3.52	0.0
Sodium	mg/L	82	56	-31.7	78	72	-7.7	69	63	-8.7

= mg L^{-1} equivalent $CaCO_3$

The sodium adsorption ratio (SAR) has not been influenced by the peat treatment except during the initial phases when calcium from the peat reduced the SAR.

4 Evaluation of the System

4.1 Maintenance and peat bed size

The low level of maintenance, less than two hours in 13 years, has been a distinct advantage of the system while the availability of the effluent for landscaping around the home has been used to add value and greater aesthetic quality to the property. An incident where a bull demolished part of the distribution system over the peat lead to the need to provide high-quality fencing of the peat bed. The damage caused during that incident was only partly rectified and may have reduced the capacity of the bed to treat the STE. The loss of phosphorus removal capacity may have been a result of that loss of area. However, the resulting reduction in treatment area suggests that the 18 m^2 designed for the household was excess to requirements. An improved design may have been to reduce the surface area to 12 m^2, while increasing the depth of the peat layer, to contain the same volume of peat. Thus, distribution of the effluent more evenly over the surface would not have presented the same problems.

4.2 Benefits from the use of peat

Three benefits are immediately available from the use of the peat bed system for treating STE. Firstly, there is a reduction in odour, suspended solids and slime. The low BOD_5 levels indicate the high quality of the treated effluent. The formation of a clogging layer at the surface of the peat bed, and the loss of the level surface on which the distribution pipes sat, were two problems encountered with the experimental system. This layer did not appear to affect the operation of the system and was not a cause of odour or insects.

Secondly, the availability of the majority of the nitrogen products as ammonium ions presents a significant benefit to surface application of the peat bed effluent. The ammonium ions are readily available for plant uptake as well as for adsorption to cation exchange sites on clay micelles and organic colloids. The latter adsorption benefits the retention of nitrogen products in the soil and renders removal in percolating effluent less likely. Overall, a 69% reduction in TN significantly reduced potential for off-site effects.

Thirdly, the availability of clean, odour free effluent with significantly reduced (99.6%) bacterial load, without any chemical disinfections, has significant advantages in increasing environmental enhancement around the house.

The major restriction in the use of the peat bed for pre-treatment of the effluent is that soon after commencement, cations in the STE are no longer adsorbed by the peat and they flush through the system in concentrations equivalent to that of the influent STE. Likewise once the peat's phosphorus adsorption capacity has been satisfied, phosphorus showed only a small decline, mostly due to the removal of suspended solids. Some phosphorus can be removed through uptake by vegetation invading the bed. It is desirable that some harvesting of the vegetation be undertaken to remove some phosphorus, although no harvesting has occurred on this peat bed.

5 Conclusions

Pre-treatment of STE through a 500 mm deep bed of peat has reduced the suspended solids (turbidity), BOD_5, and FC to levels suitable for application to landscape areas. At dosing rates less than 50 L m^{-2}, the experimental peat bed was successful in consistently reducing suspended solids by more than 96%, BOD_5 to levels by 90% and FC to less than 99.6% of the input populations. Odour was eliminated completely from the peat bed and there was no nuisance from insects.

The savings in land area required for on-site disposal through peat pre-treatment of domestic wastewater will benefit areas of limited subdivision potential, further minimising the adverse environmental effects resulting from failed soil absorption systems. The additional benefit is the increase in water available for landscape design where plants may access the nitrogen and phosphorus by-products and prevent their loss to either surface runoff or groundwater contamination. Under Australian conditions the added value of the water will increase domestic environmental amenity.

The need to reduce further the residual faecal coliforms to levels acceptable to regulatory authorities is important in the commercialisation of the treatment system. Subsurface disposal through modern dripper systems is perhaps the more favourable option. With significant reduction in suspended solids, malfunctioning of underground systems is less likely.

The peat bed has shown that with limited resources and a minimal energy input, pre-treatment before surface irrigation of domestic wastewater can be undertaken. The system can be installed onto a failed drainfield system, thus providing an ability to re-use water and reduce nitrate and phosphate runoff into the environment.

References

ANZECC (1992b) *Australian Water Quality Guidelines for Fresh and Marine Waters.* Australian and New Zealand Environment and Conservation Council.

APHA (1985). *Standard Methods for the Examination of Water and Wastewater.* 16th Ed. American Public Health Association. Washington.

Brooks, J.L., Rock, C.A. and Struchtemeyer, R.A. (1984). Use of peat for on-site wastewater treatment: II field studies. *J.Environ.Qual.*, 13, 524-530.

Brooks, (1980). A Field Study of the Efficiency of Sphagnum Peat As A Medium for the Treatment of Residential Wastewater. M.S. thesis. Uni. Maine, Orono.

Department of Local Government. 1998. *Environment and Health Protection Guidelines On-site Sewage Management for Single Households*. Dept. Local Government, NSW Environment Protection Authority, NSW Health, Dept. Land and Water Conservation and Department of Urban Affairs and Planning. Sydney.

NSW RWCC (1993) NSW Guidelines for Urban and Residential Use of Reclaimed Water. NSW Recycled Water Coordination Committee.

NSW Health Department. (1993). *Environmental Health Officers Manual.* NSW Health Department, Sydney.

Patterson, R.A. (1998) Household Solutions to End-of-Line Re-use. Proceedings of Water Asia-Pacific 98. 11th IWSA ASPAC Regional Conference, Sydney 2-5 November, 1998

Patterson. R. A. (1994) *On-site Treatment and Disposal of Septic Tank Effluent* . Ph.D. Thesis. Departments of Agronomy and Soil Science and Department of Resource Engineering. University of New England. Armidale.

Rock, C.A., Brooks, J.L., Bradeen, S.A. and Woodard, F.E. (1982). Treatment of septic tank effluent in a peat bed.*Proceedings 3rd Nat. Symp. Individual and Small Community Sewaqe Treatment.* Am. Soc. Ag. Engineers, Michigan, pp

Rock, C.A., Brooks, J.L., Bradeen, S.A. and Struchtemeyer, R.A. (1984a). Use of peat for on-site wastewater treatment: II. Field Studies. *J.Environ.Qual*., 13, 518-523.

Rock,C.A., Brooks,J.L., Bradeen, S.A.and Struchtemeyer, R.A. (1984b) Use of Peat for on-site Wastewater Treatment: I Laboratory Analysis. *J.Environ.Qual*. 13:518-523