Peat Treatment of Septic Tank Effluent Prior to Soil Absorption

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SUMMARY The pre-treatment of septic tank effluent by percolation through a 600mm deep bed of peat has been shown to reduce faecal coliform concentrations and potential pollutant nutrient levels to acceptable limits for re-use. An Australian reed-sedge peat has shown characteristics suitable for use within a peat bed to pre-treat typical domestic wastewater at a rate of 1500 litres per day. The final effluent is used to spray irrigate an area of landscaped garden around the dwelling, providing an effective and environmentally favourable disposal system while increasing the water available for landscape design under Australian conditions.

1 INTRODUCTION

The use of septic tanks and on-site soil absorption for the treatment and disposal of domestic wastewater has been considered a stop-gap method of domestic wastewater disposal in Australia (Gilpin, 1980). This appraisal cannot be supported since effective on-site treatment and disposal is a technologically feasible option and a legitimate use of natural resources. This is borne out by Wade (1983) who reports that 835 000 people in Australia rely upon septic tanks. A further 65 000 use other direct methods, such as deep pit latrines while an additional 2 million people do not have sewage treatment to secondary standards. However, where reticulated sewerage systems are available due to economies of scale or where residential densities are suitable, on-site disposal becomes a less preferred option.

The environmental contamination to surface and groundwater from untreated or poorly treated domestic wastewater varies from area to area, depending upon soil types and effluent loading rates. Effluent disposal into the highly permeable sands of the Perth locality results in an expected operation life of the drainfield of less than 8 years (Troyan et al., 1985) while systems sited on the yellow podzolics of Melbourne are typically undersized by a factor of four for effective on-site disposal (Brouwer, 1982). Few figures are available for failure rates or contamination incidents within New South Wales, however, discussions with local Health Inspectors would indicate a high rate of failure is common. Investigation by the author suggests a failure rate of 60% within four years of operation is typically due to undersizing of absorption area on all soil types together with the dispersion effect of sodium salts reducing the permeability (Patterson et al., 1986).

The failure of an effluent drainfield leads to surface ponding of semi-treated effluent, an anaerobic rather than aerobic condition in the soil, an accelerated biological clogging of the soil macro and micro pores and a health and environment hazard. The elimination of coliforms and potential pollutants from septic tank effluent, therefore, is of prime importance in the effective on-site disposal of domestic wastewater. This project has initiated a study into the pre-treatment of septic tank effluent prior to soil absorption using locally available peat moss as a purifying filter.

2 PEAT AS PRE-TREATMENT MEDIUM

Search has shown peat to be effective in removing phenols, odorous gases, textile dyes, ABS (alkyl benzene sulphonate) and heavy metals from a variety of municipal and industrial wastes. However, peats and muck soils (highly organic soils) have been rejected for suitability for on-site domestic effluent disposal (EPA, 1980) because of excessive permeabilities determined using standard percolation tests. The basic of this rejection has been disproved in recent years since sphagnum peat mosses have been used overseas for the pre-treatment of septic tank effluent with highly successful results. First documented by Brooks (1980), subsequent laboratory studies by Rock et al. (1984) and field work b Brooks et al. (1984) suggest that effective treatment of coliforms and nutrients is possible over a wider range of effluent qualities than first attempted. Removal of coliforms and the reduction of nitrate and phosphate levels was in the order of 60-90%. Rock et al. (1984) noted that reed sedge peat clogged after dosing for 28 days with septic tank effluent (STE) and continued their trials on sphagnum peat. Loading rates of STE into the peat bed varied from 15 to 81 mm per day with various treatment results according to packed bulk density and sphagnum variety.

The sphagnum peats offer an aerobic environment of acid conditions favouring the growth of fungi which utilise the nutrients of the influent STE, while microorganisms (anaerobes and aerobes) operate on the carbon available in the influent. It has been suggested that biological breakdown of the peat is reduced because of the availability of C in the influent, leaving the C of the peat untouched. Thus the peat forms a substrate upon which the fungi and microbes can grow while providing a reserve of C and nutrients. Brooks et al. (1984) suggest that the bacteriocidal fungi, the phenolic properties of peat and the acid aerobic environment are responsible for the almost total reduction in total and faecal coliforms. Since only a count under 2000 faecal coliform organisms per 100 ml is required to meet Australian guidelines for the re-use of wastewater (Anon, 1979) the sterilising properties of peat are more than acceptable for re-use around landscaped areas.

Domestic effluent data used in the experiments detailed above are given in Table 1 together with typical results of effluent treated in peat beds and columns. It can be seen that the removal of turbidity, 5 day biochemical oxygen demand, total P and total N are significant. However, effluent treatment does not address the problems associated with monovalent ions and the sodium absorption ratio and the dispersive effects upon soil to which the effluent is applied.

TABLE I

SEPTIC TANK EFFLUENT BEFORE AND AFTER PEAT TREATMENT

Parameter	STE	Treated	Reduction
pH	5.5-7.1	5.3-6.4	
Turbidity (NTU)	60	9	85%
TSS (mg/1)	161	16	90%
Faecal coliforms (colonies/100ml)	36 million	>20	99%
BOD5 (mg/1)	280	25	90%
Total P (mg/1)	13.8	0.5	96%
Total N	65	20	68%

The peats commercially available at present in Australia are restricted to a local reed sedge peat mined on the south coast of New South Wales, imported several New Zealand sphagnum moss peats and various German and Russian sphagnum moss peats. The primary use of peat in Australia has been the commercial horticulture industry where peat is used as a potting medium,either wholly or as a proportion of a potting mixture. It is preferred because of its reliable quality, sterility, high water holding capacity, air filled porosity and cation exchange capacity. The current annual expenditure on peat for horticulture is estimated at 20 million dollars (A. McNally, AMG, pers. comm).

A typical New Zealand peat has a water holding capacity of 98% by volume while maintaining a relatively high air-filled porosity, a pH of 4.2, an organic matter content of 97% , an air dry moisture content of 193% by weight and a salinity of 0.4milliSiemens per centimetre (Carlyon, 1985).

The formation of the reed-sedge peat and the sphagnum peat is quite different. The sphagnum peat is a semi-decomposed moss formed in a raised dome above the natural water table, the reed-sedge peat is formed in a situation of inundation below the natural water surface. The sphagnum peats in New South Wales are protected under the National Parks and Wildlife Act. The reed-sedge peats are also protected but licences have been obtained for their commercial exploitation.

3 EXPERIMENTAL METHOD

The restricted range of peats available in Australia, and possibly the need to support local industry has resulted in a laboratory experiment to evaluate the potential for two peats and an inert porous material to treat septic tank effluent prior to soil disposal. A New Zealand sphagnum moss peat ("Warrior"), the local AMG's reed-sedge peat and the inert "Growool" (Trademark - Bradford Insulation) were chosen to represent both the physical and biological processes of treatment. Growool is a bonded form of crude natural glass fibres, non-biodegradable, inert with a cation exchange capacity near zero. The Growool was expected to provide a non-carbon based substrate upon which the fungi and microbes could grow while providing a control against which the two peats could be evaluated. It was expected, however, that the Growool would function similarly, allowing treatment of the effluent for coliform and nutrient removal.

750mm tall columns were made from 100mm PVC sewage pipe and packed with a base layer of 100mm of 15-30mm gravel (crushed basalt) and 600mm of the respective material (peat or Growool). The Growool was cut into a 100mm column using a specially made tool to prevent the formation of voids between the medium and the wall of the column. The lineation of the fibres of the Growool were parallel to the long axis of the column, a feature not considered detrimental to the treatment process. The only effect of this orientation was to reduce the water holding capacity by approximately 20% over the 600mm column. Bulk density of the packed Growool column was 85kg per cubic metre. The New Zealand and local peats were packed to oven dry bulk densities of 101 and 159kg per cubic metre respectively. Oven dry bulk densities were used because of the variation in moisture of similar peat bales, The difference between the two peats was a direct result of the greater proportion of coarse lignified material in the reed-sedge peat. However, in light of the results obtained by Rock <u>et al</u>. (1984) the higher reed-sedge bulk density is not considered detrimental to treatment potential. Water holding capacities (equivalent field capacities) were measured as 94%, 74% and 92% by volume for the New Zealand, Australian and European peats respectively while Growool was approximately 77% by volume.

Five columns for each medium were prepared for treatment as follows:

(a) 1 control column to be treated with tap water;

(b) 2 columns to be dosed at a rate of 41mm per day; and

(c) 2 columns to be dosed at a rate of 82mm per day.

The 41mm rate was that rate evaluated by Rock <u>et al</u>. (1984) as giving the most successful treatment of the effluent. For the purpose of overloading the system, 82mm was considered an appropriate rate.

The columns were held in a fume chamber to prevent unpleasant odour contamination of the laboratory and isolate potential bacterial hazards from other staff. A constant temperature of 20-25 degrees was maintained over the period of the test. At the time of writing the experiment had been operating for 10 weeks. It was envisaged that the laboratory work would continue another 6 weeks until the field trial could be commenced. The columns were dosed each week day with a single dose representing the dose rate for that column.

Daily sampled of the effluent were taken from the senior author's septic tank and used to dose the columns within 30 minutes of collection. A filtered sample of the daily sample was frozen and stored for further analysis while pH and electrical conductivity measurements were made on the fresh sample.

Weekly samples were taken from each column and measured for the following:

(a) pH, electrical conductivity - direct measurements;

(b) Na and K - using flame photometry;

(c) Ca and Mg - using. atomic absorption spectrometry;

(d) nitrate - using ultraviolet photometry initially supported by persulphate digestion; and

(e) phosphate using molybdenmum blue colorimetric techniques.

The biological populations of the columns were permitted time to grow before measurements were made of the reduction in coliforms and biochemical oxygen demand. At the time of writing only two counts of faecal coliforms had been made but the results had reached a satisfactorily low level. Insufficient effluent was available for BOD measurements and will be undertaken at a later stage.

Initial quantification of the cations and cation exchange capacities were measured for the peats available to gauge the ability of those peats in buffering the sodium levels expected through the effluent.

4 RESULTS

4.1 Peat Quality

Table II below indicates the cation exchange qualities of the two peats used together with a European peat. The latter was omitted from further trails in preference to the New Zealand peat because of a price differential of almost 50% on bulk purchases. The lower exchangeable sodium percentage of the reed-sedge peat is considered important only in initial stages of treatment, however, the cation exchange capacity (CEC) will affect the total cation retention capacity and the buffer against excessive sodium levels.

4.2 Changes to column pH

It was stated previously that an acidic environment was necessary for promoting bacteriocidal fungi and other consumers of effluent pathogens. The STE varied over the range of 6.8 - 8.0 depending upon the antecedent water use. Following wash days the pH was more alkaline than when washing was not the major water use. The pH of the columns were initially 5.1-5.8, 6.4-7.8 and 8.2-9.0 for the New Zealand peat, local peat and Growool respectively. Flushing the columns with tap water had little effect upon the pH, but the treatment with effluent has resulted in ranges of 4.2-4.8, 4.7-6.4 and 5.4-7.3 for the columns as for the previous order. The higher values within each range result from the 81mm dosing rates.

TABLE II

QUALITIES OF THREE PEATS AVAILABLE IN AUSTRALIA

Peat	Na	K	Ca	Mg	CEC	ESP
	(all units milliequivalents/100 g peat)					
New Zealand (sphagnum)	2.6	0.9	26.0	15.5	118	2.3
Australian (reed-sedge)	0.5	0.5	15.0	3.0	50	1.1
European (sphagnum)	1.4	0.5	9.6	9.0	100	1.4

4.3 Electrical conductivity

As a measure of the total dissolved salts contained in the effluent, the electrical conductivity of the STE was static at 1.4 mS/cm while tap water (local Armidale supply) was 0.4mS/cm. Initial electrical conductivity for the New Zealand peat was 2.2 mS/cm, while the local peat was 0.4mS/cm. To the present time, the conductivities for the former have stabilised around 2.0 while the local peat and the Growool are around 1.3mS/cm.

4.4 Cations

Except for the Growool, there was an initial slump in the level of sodium, potassium, calcium and magnesium ions flushing through the columns. From STE levels of 125, 30, 10 and 4 mg/l respectively, present levels are 100, 20, 0-50 and 6-20 respectively. The high levels of cations in the effluent appear to have satisfied the cation exchange over the first few weeks and the excess of sodium ions are now flushing the calcium and magnesium from those exchange sites. It is suggested that the level of those divalent cations will equilibrate with the effluent. A mechanism for removal of those ions, precipitation, is not similarly available to the sodium. This means that sodium ions will always be in solution, able to move with the water flux and affect the dispersion of colloids.

4.5 Faecal coliforms

With insufficient time for the microbial population to reach a climax, removal of coliforms is lower than would be expected at a later stage. However, there is a significant difference among the columns. The STE had colonies too numerous to count (TNC) while those flushed with tap water varied from 0-4. The local peat at the 82mm rate was towards the lower end of a 700-TNC range, followed by the 41mm local(1200), 41mm NZ (1700) and 41mm Growool(2000). The other columns tended towards the TNC range. It is to be noted that there was a removal of coliforms in the Growool, indicating that a favourable environment for purification was being reached. Further sampling will continue.

4.6 Phosphates and nitrates.

The level of nitrate removal for the local peat and the Growool was greater at the 82mm dose than the lower 42mm dose. Reduction levels ranged from 20% to 40%. In three samples there was an increase in nitrate, due possibly to the conversion of N-products to nitrates. The colour flushed from the New Zealand peat continued to mask the values of nitrate in those columns and other methods of analysis were used taking account of the high background flushing using tap water.

The initial phosphate level of STE was 4.6mg/l while ranges within the column after accounting for background value of the tap water control were from less than 0.1 to 4.8. Initially the local peat was removing the greater percentage of phosphate followed by the New Zealand then by the Growool. After six weeks the Growool had ceased removing phosphate and the level had stabilised with influent phosphate levels. The New Zealand peat was initially flushing 2.9mg/l under tap water input, this dropped to background levels of 0.9 after six weeks.

4.7 Colour, turbidity and odour

A strong mustard yellow colour flushed from the New Zealand peat continued into the eighth week, affecting the readings for phosphates and nitrates. However, in all columns from week 3 the turbidity of each column effluents gave an identical reading with a sample of untreated effluent after having been filtered through a 0.45 micron filter. The columns were removing 99% of the suspended solids, with little or no difference between the two rates or among the samples. There was no visual difference in clarity between the treated effluent and tap water.

The odour of the effluent directly from the septic tank was overpowering and obnoxious to other laboratory users. Odour from the treated effluent was undetectable and once ponded effluent had disappeared from the column it too was odour free.

5 DISCUSSION

The implications of the preliminary results of the laboratory columns are that there is an effective medium for the pre-treatment of septic tank effluent such that a reduction in faecal coliforms can be met. The exact level is yet to be determined, however, those experimental columns have indicated that a level of less than 2000 colonies per 100 ml has been achieved at an early stage of treatment. Further evaluation of the removal of phosphate and nitrate must be undertaken, however, where the treated effluent is disposed of by spray irrigation to landscaped areas, the advantage to plants of the additional nutrients will not create the environmental problems associated with the characteristic wet spots of failed drainfields and the associated anaerobic conditions.

The dosing rates of the columns of 41 and 82 mm did not show a marked difference in ability to remove coliforms while the high rate on the local peat column indicated the most successful treatment in terms of reducing health risks and environmental hazards. This effect may be due to the initially higher N and P in the 82mm column which provides a boost to system growth during the early stages of population growth. The benefit derived from the performance of the 81mm column is that the size of a domestic pre-treatment system could be reduced by half,a saving of hundreds of dollars.

There is, however, a real complication from sodium as it is related to soil dispersion. In the traditional drainfield, there is evidence to show a direct loss of soil permeability as a result of high sodium ion loadings. Where an irrigation system is employed, surface treatment with gypsum could be used to overcome dispersion problems. Further, should a soil system under irrigation fail, the system can be moved more economically than creating a new drainfield.

6 DOMESTIC PRE-TREATMENT SYSTEM

As a result of the preliminary tests above, a full size domestic pre-treatment system will be constructed to treat 1500 litres of septic tank effluent daily. The peat bed will contain Australian peat to a depth of 600 mm and receive a dosing at a maximum rate of 81mm per day. Thus the dimensions will be 18.5 square metres designed as a bed 6m x 3.1m having a volume of 11 cubic metres of peat at an oven dry bulk density of approximately 160kg per cubic metre. The cost of the peat at 1986 values would be approximately $250.

The septic tank effluent will gravity feed a distribution system, percolating through the 600mm depth of peat to a gravel bed underneath for collection in a sump. An automated microspray sprinkler system will distribute the treated effluent to a area of landscaped garden. Due to the reduction in biological content of the treated effluent and the removal of suspended solids, clogging of the sprinklers is not considered a maintenance problem. However, to overcome algal growth the system will self drain following each application. Local evapotranspiration requirements in landscape areas will vary with soil type and density of planting, however, a minimum of 100 trees and shrubs have been selected for the trial occupying an area equivalent to four suburban blocks. An initial dose of gypsum at the rate equivalent to 2 tonnes per hectare will be applied under each sprinkler. The system will be monitored over a two year period to determine effectiveness and sample soil chemical and physical properties together with coliform counts at specific locations.

7 CONCLUSIONS

The pre-treatment of septic tank effluent will reduce the coliform and nutrient status to within re-use guidelines for application to landscape areas. The saving in land area devoted to on-site disposal on domestic wastewater will benefit areas of limited subdivision potential while minimising environmental effects resulting from failed soil absorption systems. Further, the increase in water available for landscape design under Australian conditions will increase environmental amenity.

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