RURAL SUBDIVISION BASED ON SEPTIC TANK EFFLUENT DISPOSAL

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Summary

On-site effluent disposal in rural areas is a legitimate use of resources and provides an excellent purification of effluent when unsaturated soil moisture conditions are maintained. There are several acceptable methods of soil absorption such as traditional drainfields, mounds and evapotranspiration beds, however, each relies upon the efficiency of the septic tank and the dosing rate of the soil. Both the septic tank and the drainfield dosing systems are generally misunderstood by both the community and local authorities. Thus, there is a need for developing standards for rural subdivision allotment sizes based upon safe disposal of septic tank effluent incorporating a measure of safety because of the mismanagement of present systems.

Keywords: septic tanks, drainfields, mounds, evapotranspiration beds, dosing rates, maintenance, minimum field sizes, subdivision areas, failures,

1. Introduction

Reticulated sewage treatment systems are often considered the ultimate wastewater disposal mechanism, collecting all wastes from domestic households, conveying them to a central treatment complex and disposing of the treated effluent back to the hydrologic cycle. The latter disposal is usually a return of the effluent to the river from which it was derived. Septic tanks with the associated soil disposal of effluent are accorded a second rate classification, a position not justified in either economic or environmental terms. Soil absorption of septic tank effluent from domestic households is a legitimate use of resources and an environmentally sound practice, when the design criteria match the particular landscape. The advantages and disadvantages of the two systems will not be addressed here, but rather the implication of planning for subdivisions based upon the use of the soil as a treatment mechanism. However, it is necessary that many of the fallacies and misconceptions of on-site treatment and disposal are clarified.

This paper will examine some of the omissions in present planning and management of septic tanks; the methods of soil absorption including the traditional drainfields and alternate methods of absorption; minimum setbacks of absorption areas from creeks, waterways and boundaries. Finally the use of soil absorption will be reviewed in relation to minimum areas for rural residential subdivisions based upon the above requirements and the design criteria for the regional and landscape constraints.

2, System Function

A septic tank is a water tight compartment capable of accepting all household wastes. In New South Wales 'black water' (toilet wastes) and 'grey water' (other wastes) are required to be treated before disposal to the environment. All discussion beyond this point will refer to wastewater as the composite of both grey and black waters. The function of the septic tank is to provide primary treatment of the wastewater by means of:

(a) floatation of scum and wastes less dense than water, these include body greases, kitchen greases and froths:

(b) sedimentation of particles more dense than water, including those flocculated within the tank by contact with cations and other flocculating agents: and

(c) anaerobic digestion of the three products - the scum, the sediment and the effluent.

Under the processes of partial digestion (decomposition) which occurs within the septic tank, the suspended and soluble organic load of the wastewater is reduced. The following table illustrates the average loading rates for domestic septic tanks and the average effluent quality following a detention storage period of not less than 24hrs.

TABLE 1

DOMESTIC WASTEWATER AND EFFLUENT QUALITY

Organic compounds	Wastewater mgL^{-1} (a)	Effluent mgL^{-1} (b)
Solids		
total dissolved	600-1000	165
total suspended	200-300	70
Biochemical oxygen demand	200-300	130
Chemical oxygen demand	680-730	300
Nitrogen - total	35-100	50
Phosphorus - total	18-30	12

(a) US.EPA, 1980 (b) Otis and Boyle, 1976

The values for the treated effluent given above are higher than the allowable concentration required by the Clean Waters Act(1970) which stipulates a minimum of 20 milligrams per litre BOD 5 days and 30 milligrams per litre suspended solids. There is a requirement for further treatment before release to the environment . The soil absorption system provides the additional removal of pollutants. Correct dosing of a soil absorption system, such that treatment is aerobically performed, should result in a wastewater having qualities below the minimum standard. Brouwer (1982) suggests that treatment in the soil is complete after percolation through 2 metres of unsaturated soil and 30 metres of saturated profile. The zone of saturation however, depends upon the dosing rate of the soil absorption system, that is the volume of water released on a daily basis in relation to the subsoil disposal area available. The literature generally suggests that removal of nitrogen and phosphorus is almost complete within the soil system, a benefit not afforded to reticulated treatment systems.

3. System Loading Rates

The loading rate of a septic tank is dependent upon the use of water within the household. Patterson (1985) found that households totally reliant upon rainwater consumed on average 165 litres per person per day but those connected to a reticulated supply used 350 litres per person per day. Thus, a household water consumption as suggested by the State Pollution Control Commission (1978) of 240 litres per person per day is a reasonable estimate except for town water connections. A loading rate per household of 1500 litres per day is considered an average effluent loading. It becomes obvious that conservation within the household reduces the need for large soil absorption fields, while extravagant use of water will lead to overloading problems.

4 Effluent Disposal Mechanisms

4.1 General

There are several systems available for disposing of septic tank effluent to the environment through a soil interface. These include the traditional drainfield, evapotranspiration beds, mounds, filters and irrigation disposal. Each of these will be examined briefly to outline the minimum requirements for each.

4.2 Traditional Drainfields

The effluent is disposed to a subsoil environment where water ponded to depths of less than 50mm is absorbed through the bottom and sidewall areas of a trench. Typically the trench has dimensions of 900mm wide by 450mm deep with lengths up to 120 metres. It is unfortunate that common practice has resulted in many trenches being underdesigned at 30 metres. There is, however, no satisfactory guide for dosing rates, since design criteria overestimate bottom absorption while ignoring evapotranspiration. A household using 1500 litres per day requires a trench of at least 80 metres irrespective of soil type, problem soils require longer trenches.

4.3 Evapotranspiration Beds.

This system relies entirely upon the evapotranspiration potential of a well maintained and highly evaporative plant community to remove effluent, from a sealed bed of porous material, to the atmosphere. The constraints upon the effective long term operation of such a system requires management levels beyond the ability of many householders. The system suffers from an inability to resurrect a failed system. Where systems have been designed for the local environment, the safety factor for overloading has resulted in large area beds (500m^2) being required. The cost of such approaches the prohibitive when other resources are available.

4.4 Mounds

Ideally, these are disposal fields constructed on the surface of the soil and a mound over the disposal pipe allows the removal of effluent through both infiltration and evapotranspiration. Where these systems have been used in America on problem soils, the disposal has been successful (Converse et al, 1978). Their employment in Australia is becoming popular but should be used in combination with double chambered tanks. Typical mounds for Eastern Australia have dimensions of 5 metres wide and 20 metres long.

4.5 Filter Beds and Irrigation,

Recent experiments with the use of peat (sphagnum) filter beds to remove the pollutants from the septic tank effluent have been very successful. Filter beds having dimensions of 4 metres by 6 metres by 600mm deep have removed 95% of nitrogen and phosphorus, 100% coliform bacteria from domestic effluent (Rock et al, 1984). At a rate of purification of this level application by irrigation is acceptable to areas used for public access.

5. Common Fallacies

(a) Septic tanks are management free - False.

There is need for management of the products disposed to a septic tank. Cigarette butts, large loadings of paper, kitchen scraps passing through a garbage grinder and plastic materials should be prevented from entering the system. A septic tank is not management free but requires careful monitoring of input solids and water volume.

(b) Septic tanks last for years - False.

The three functions performed by the septic tank result in a build up of indigestible sediments and scum, thereby reducing the storage capacity of the liquid effluent. When the liquid storage volume is less than the daily inflow of wastewater, the reduced detention time results in the discharge effluent increasing in organic load. This increase quickly affects the clogging layers in the absorption field, blocking essential disposal paths and reducing the efficiency of the soil treatment process. Septic tanks should be pumped out every two to three years as a minimum requirement.

(c) Absorption fields can be designed on soil percolation tests - False.

The standard soil percolation test as required by some authorities is based upon outdated information in relation to effluent disposal. Firstly, the percolation test is based upon the movement of clean water through a test hole. Secondly, the test is designed to measure the infiltration of water through the bottom of the test hole and avoids the complication of sidewall movement. Finally, the percolation test makes no account for potential evapotranspiration from vegetative materials. It has been suggested by Olivieri et al (1981) that the better testing procedure is through local inspection of existing trenches and classification of soil and landscape according to present correctly functioning systems.

(d) The present methods of construction are satisfactory - False.

Present construction standards fail to mention smearing of sidewalls and bottom areas of trenches, avoid restricting depth of trenches to the infiltrative horizons of the soil and fail to allow for evapotranspiration.

While standards exist for the physical construction and sizing of the septic tank (AS 1546), there are no standards for applying dosing rates to soil types and no guidelines for the capabilities of the landscape for the various disposal methods. Victoria has taken steps towards these ends (Brouwer and Bugeja, 1983) but other States are slow to follow.

6. Setbacks.

A setback is the minimum safe distance of a soil absorption field from another service, water resource or boundary line. Little experimentation has been carried out on the safe distances based upon faecal coliforms, nitrogen and phosphorus as the indicators of pollution. Brouwer (1982) has suggested setbacks based upon his studies with traditional drainfields on problem soils in Victoria. No other Australian data are available and estimates have to be made from the literature based upon the effectiveness is dependent upon soil texture (particle size analysis), the unsaturated zone and the retention time available. In view of the lack of data, it is suggested that the estimates by Brouwer (1982) serve as a guide to minimum distances and where rainfall increases soil moisture to near saturated conditions that a further increased estimate be made.

TABLE 2

RECOMMENDED SETBACK DISTANCES FOR VICTORIA (Brouwer,1982)

Item	Setback (m)
Streams	25
Lakes, large well flushed	50
poorly flushed	100
Cuttings, escarpments	25
Wells, dams, ponds	100
Buildings	2
Driveways	2
Boundaries	2 high side 4 low side

These setbacks should be measured from the known maximum extent of the wetted effluent front and not simply from the centre line of the absorption field. Where evapotranspiration beds are used there is no requirement for setbacks since the total volume of the effluent is disposed to the atmosphere. There is, however, need to preserve an unrestricted airflow over the bed and allow for maximisation of available solar radiation onto the bed.

7. Restrictions for Rural Subdivision.

In a study commissioned by the Grafton City Council, Patterson and Perrens (1983) presented guidelines for the minimum rural residential subdivision areas based upon several effluent disposal methods. A residential subdivision must allow usable space for house and garage, legal setbacks from roadways, clear space for recreation, lawns and gardens and an area specifically for effluent disposal. The allocation of this area must be suitable for safe disposal of total household effluent at a minimum rate of 1500 litres per household per day. Calculations must be based upon at least the 86th percentile rainfall value since average success (50% of the time) is less than satisfactory from either a health or environmental aspect.

The Grafton guidelines suggested a minimum area of 1.5 hectares where mounds were employed to dispose of effluent, that is on slopes of less than 6%. On slopes greater than 6% where it was necessary to use conventional trenches, up to 2 hectares were required to provide both the living space and the effluent disposal area.

Since the effluent disposal area is a specific use area, activities which would alter the disposal qualities of the soil must be restricted. The construction of fences around the disposal area may be required to prevent vehicular or animal access.

8. Conclusion.

Several methods of environmentally sound disposal of septic tank effluent have been illustrated in the above sections. The assessment of the landscape to accommodate one or more of the systems can only be made by on-site inspections of actual soil conditions and the local environmental constraints upon dosing rates and sizing of the disposal field. The percolation test has lost favour with designing requirements, while there is great variation in the household water use where various sources of water are available.

.Common failures in septic tank disposal fields result from three causes:

(1) incorrect sizing of the disposal field in relation to the household water use and the soil's disposal capacity;

(2) poor construction techniques employed in excavation backfilling, levelling and the selection of backfill material; and

(3) poor maintenance of the loading of the septic tank, the maintenance of a daily retention storage and prevention of overflow of effluent of above average solid content.

Minimum allotment areas must be based upon both the requirements for living space and on-site effluent disposal, the latter area requiring exclusion from normal activities. Where the common causes of failure can be eliminated through local authority involvement and adequate guidelines for construction agencies, the minimum areas may be relaxed. However, failed soil absorption systems present environmental and health hazards to the community and rejuvenation is both a costly and inconvenient process.

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