Skills to Assess the Suitability of Sites for On-Site Wastewater Disposal

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Abstract

Raised public expectation and increasing political pressure in the face of mounting evidence that substantial numbers of on-site wastewater disposal systems perform poorly or fail, has resulted in the revision of State Government Guidelines and the Australian Standard 1547. These revised guidelines require a wider range of skills of Environmental Health Officers and others involved with the management of on-site wastewater systems. In response to the increased demand for training in this area the Centre for Environmental Training, already established as the leading provider of training in on-site wastewater in Australia, has developed a revised and updated On-site Wastewater Management Training Program. A key element of this program is the practical assessment of soils as a guide to the suitability of sites for on-site wastewater disposal. The workshop will provide participants with an introduction to the skills of soil assessment.

Introduction

In excess of 2 million people in Australia rely on on-site systems for the treatment and disposal of domestic wastewater (Patterson, 1993). Amongst these on-site systems are septic tanks, an increasing number of aerated wastewater treatment (AWT) systems (Rawlinson, 1994) and composting toilets with greywater treatment.

There is considerable evidence from a number of recent studies (Martens & Warner, 1995; Geary, 1992) and surveys undertaken by and on behalf of Local Councils, that pathogen and nutrient export from underperforming septic absorption trenches and AWT systems has an adverse effect on the environment and significant implications for environmental health (Gardner *et al*, 1997).

The performance of on-site wastewater disposal systems has been of concern in sensitive coastal catchments (Whitehead, 1997) and has been brought to the fore with the Hepatitis outbreak in Wallis Lake. Some parts of the Sydney water supply catchment are unsewered and have significant densities of on-site wastewater disposal systems. The contamination of the Sydney water supply in recent times is potentially attributable to poor performance or failure of on-site systems in the catchment.

Environmental Impacts of Failing On-Site Systems

In situations where on-site systems fail or underperform, untreated or partially treated effluent may inadvertently pollute surface or groundwaters. At a number of locations within Australia, there is considerable evidence that the export of nutrients and pathogens from catchments serviced by poorly performing on-site systems is having an impact on receiving waters (Martens & Warner, 1995; Beard *et al*., 1994) . There are also potential public health impacts wherever contaminated surface water is reused for potable or recreational purposes.

Groundwater may become polluted if significant concentrations of contaminants reach the water table. On-site disposal of effluent in domestic situations relies on soil absorption and a zone of unsaturated soil underneath the disposal field. The major processes which act to attenuate contaminants in this zone are filtration, sorption and chemical precipitation. With an inadequate unsaturated separation distance between the disposal field and the water table, pollutants present in domestic wastewaters may be only partially treated and enter the groundwater (Canter & Knox, 1985).

While there have been a large number of groundwater pollution incidents reported in areas of high on~site system density in the United States (Weiskel & Howes, 1992),

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similar investigations have only rarely been conducted in Australia. One detailed study at Benalla in Victoria (Murray Darling Basin Commission, 1993) found that significant levels of bacterial and nitrate contamination in groundwater were due to a high density of on-site effluent disposal systems in the area studied. Perhaps the most important conclusion from this investigation is that groundwater in areas of the Murray-Darling Basin which have septic tank densities greater than 15 tanks/km^2 are considered to be vulnerable to nitrate and microbial contamination.

Transport of Major Contaminants

Potential contaminants from on-site disposal systems are phosphorus, nitrogen, chloride, metals and pathogens. Their fate depends on how they interact with the soil and soil solution.

Phosphorus - Although the potential mobility of phosphate through soil is high due to its solubility in water, phosphate is usually attenuated in soil by sorption and precipitation. In general most Australian soils have high capacities to immobilise phosphate ions from septic tank effluent and therefore limit the subsurface transport of this nutrient. Adverse groundwater consequences of phosphate leaching are likely to be the exception rather than the rule.

Nitrogen - Within septic tank effluent the total nitrogen concentrations consist of about 75% ammonium and 25% organic nitrogen. In an unsaturated zone under a disposal field, aerobic activity results in the almost total conversion of ammonium into nitrate. As a result, nitrogen in the form of nitrate usually reaches groundwater and is highly mobile due to its solubility. The rate at which nitrate percolates downward from the disposal site to the groundwater therefore depends on the soil/rock permeabilities, depth to the saturated zone and volume of recharge to the soil. Once in the groundwater system, the movement of nitrates is highly dependent on the hydraulics and hydrogeology of the aquifer.

Pathogens - Pathogens are removed from effluent in unsaturated soil by filtration, adsorption and by their limited survival period. Under most conditions, the reduced temperature in the soil and a decline in the availability of nutrients and carbon results in the development of a barrier to the migration of pathogens to groundwater. The period of time required for pathogens to migrate towards the water table also depends on the soil/ rock permeabilities, depth to the watertable and the volume of recharge to the soil. Various studies which have been conducted on the survival times of bacteria and viruses in groundwater show that several environmental factors such as hydraulic loading rate, soil and geological characteristics and nature of the aquifer can all affect contaminant migration (Canter & Knox, 1985). However, it is still possible for some pathogens to survive under certain conditions and for there to be a public health risk if groundwater is to be reused for potable purposes.

Environmental Health Guidelines

Phosphorus and nitrogen are nutrients which can contribute to eutrophication in surface water bodies. Maximum levels are set for effluent discharges to surface water systems to prevent water sources becoming, eutrophic. The recently published Australian Drinking, Water Guidelines (NH&MRC, 1996) provide guidance with respect to possible contaminants in drinking water, irrespective of whether the water source is groundwater or a surface supply. The relevant contaminants in groundwater where it may be used for a drinking water supply are nitrate and bacteria. Given that it is known that effluent from on-site systems can under certain conditions contaminate groundwater, it is appropriate to examine the standards which exist for these contaminants where there is a potential for water reuse.

The NH&MRC (1996) Guideline for Australian Drinking Water states that based on health considerations 50 mg-NO_3/L (as nitrate) has been set to protect bottle fed infants under 3 months of age. Concentrations higher than this have been reported to cause methaemoglobinaemia in infants. Up to 100 mg-NO_3 /L (as nitrate) can be safely consumed by adults and older children. In most Australian reticulated supplies, nitrate concentrations range up to 1 8 mg-NO_3/L with typical concentration less than 0. 15 mg-NO_3/L. As nitrate is formed from the oxidation of organic wastes, its presence in high concentrations in groundwater may indicate contamination from on-site effluent disposal systems.

Coliform bacteria and thermotolerant conforms (or alternatively E.coli) are commonly used as indicators of the safety of water for drinking. They should not be detected in any sample of drinking water, and if detected, immediate action such as treatment is required. While coliform bacteria and thermotolerant conforms are not generally pathogenic, they are useful indicators of the possible presence of pathogens and/or the cleanliness of the water supply. They could be used to indicate possible contamination from on-site effluent disposal systems, although other potential sources may also be responsible.

Methodological Approaches

Desk Top/Field Investigations - Investigations into the vulnerability of groundwater to septic tank effluent have been undertaken in a number of different ways. In most studies an initial examination of the soils, geology and hydrogeology of the region in the form of a desk top study is undertaken. This is followed by field work in which groundwater samples are collected and analysed for a number of water quality indicators.

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Nitrate in groundwater is dependent primarily on the mass of nitrogen discharged to the soil, the hydraulic characteristics of the soil and the depth to groundwater. It is, therefore, often used to indicate contamination in areas where there are high densities of on-site systems. Pathogens are sometimes used as well, however, due to their mortality rate, the lower soil and water temperatures, and the possibility of contamination from other sources, they are less likely to be present in groundwaters.

In this approach a large number of groundwater samples must be collected and analysed and the results interpreted in relation to the regional hydrogeology and the density of on-site systems. An approach such as this confirmed that high levels of contamination in the Benalla region in Victoria were due to the high levels of septic tanks in the study area (Murray Darling Basin Commission, 1993).

Modelling/Risk Assessment - An approach which is regularly used to control groundwater contamination from on-site systems is to use setback distances and then specify the density of development in new subdivisions. Sometimes this is based on modelling and risk assessment, although often setbacks are just simply a recognition of the need to create a buffer and are arbitrarily chosen.

Bechdol *et al*. (1994) developed a USEPA approved viral fate model to evaluate the risk of well contamination from septic system discharges while Anderson *et al*. (1987) reported the use of computer simulations to model contaminant transport under varying hydrologic regimes in locations with high on-site system densities. Within Australia, Beavers & Gardner (1993) have developed a decay model for calculating setback distances of septic tanks from potable bores and streams based on the survival time of viruses in groundwater. Jelliffe (1995), too, has developed a method to estimate phosphorus export fromseptic trenches and used this to determine desired lot densities.

Risk assessment methods to assess groundwater vulnerability to septic tank effluent are described by Canter & Knox (1985) and in the Murray Darling Basin Commission (1993) report on Benalla. These empirical approaches rely on broad geological and hydrogeological parameters to provide an assessment Of groundwater vulnerability to on-site systems.

On the basis of the above field investigations and modelling approaches, it appears that the most important factor influencing groundwater contamination by septic tank effluent is the density of systems (Yates, 1985). Catchment scale studies have recorded groundwater contamination in aquifers underlying permeable soils where septic tank density exceeds 15/km^2 (ie. 1/4ha) for potable groundwater protection. The degree to which groundwater contamination is acceptable depends on the beneficial long term use of the aquifer, however several case studies have confirmed nitrate and. bacterial contamination of groundwater in unsewered communities with small lot sizes.

Regulatory reform

Heightened public awareness and increasing political pressure together with mounting evidence that previous guidelines were not serving to adequately protect environmental health, has resulted in the review of Australian Standard 1547, a revision of which is due for publication shortly, and the publication of the Environment & Health Protection Guidelines, On-site Sewage Management for Single Households (NSW Department of Local Government, 1998). The application of the raised standards required by these changing regulations places additional demands on Environmental Health Officers and others charged with their implementation. These new regulations clearly indicate that there is scope for enhanced training in aspects of on-site wastewater management as Environmental Health Officers are called upon to practice an increasing range of skills in their day to day work. The most comprehensive and widely available professional short course in on-site wastewater management available in Australia is the On-site Wastewater Management Training Program offered by the Centre for Environmental Training (Centre for Environmental Training, 1998). This program has recently been revised and extended to fulfil the training requirements of Local Government practitioners demanded by the new guidelines and revised Australian Standard. One key area which this short course covers is site assessment for on-site wastewater disposal.

Site assessment for on-site wastewater disposal

Frequently, poor performance or failure of on-site systems can be attributed to inadequate assessment and understanding of soils. Amongst the skills required of those assessing sites for suitability for on-site wastewater disposal are: identification of those soil morphological properties that relate to wastewater disposal, the ability to relate soil morphological properties to the potential soil - water relationship, the ability to rate the potential of a soil for effective wastewater disposal, the development of strategies for improving the wastewater acceptance potential of soils and an understanding of those soil properties that should be monitored (Patterson, 1997).

The recently released NSW Guidelines and the shortly to be released revision of Australian Standard 1547 place increased reliance on soil assessment in the determination of effluent loading rates in disposal areas. They move away from the previous reliance on a percolation test for the determination of Long Term Acceptance Rate and Design Irrigation Rate and towards the use of measured permeability or permeability inferred from soil textural analysis to assign a Design Loading Rate.

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Amongst the soils related workshop based components of the On-site Wastewater Management Training Program are sessions on the determination of soil dispersivity, determination of field texture, investigation of the effect of effluent quality on hydraulic conductivity, land capability assessment and the field assessment of soils, each of which is covered comprehensively in the On-site Wastewater Management Training Program course notes (Patterson, 1 997).

The workshop session will provide a hands on introduction to the soil assessment skills required to adequately assess the suitability of' sites for on-site wastewater disposal.

On-site Wastewater Management Training Program

Further details of the On-site Wastewater Management Training Program can he obtained from the Centre for Environmental Training, 33 Rae Street, Birmingham Gardens, NSW 2287, Australia. Telephone 02 4955 6656-Facsimile 02 4965 6656, Email cet-hunterlink.net.au

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