FUTURE DIRECTIONS AND BEST MANAGEMENT PRACTICE FOR ON-SITE WASTEWATER SYSTEMS

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Abstract

The papers presented at On-site '03 contain a wealth of research, investigation and case study information, with wide ranging implications for future directions in best management practice for on-site wastewater systems. Addressing key issues arising from the contributions to On-site '03 can best be achieved through efforts by NOSSIG (the National On-site Systems Special Interest Group of AWA for Australia) and SWANS-SIG (SIG (the Small Wastewater and Natural Systems Special Interest Group of NZWWA for New Zealand) in initiating development of best practice position papers and guidelines.

Keywords

on-site wastewater, treatment, land application, water reclamation, management

1 Introduction

Some forty-five papers have been offered for On-site '03 covering a wide range of themes and topic areas. These themes are discussed below in the context of current on-site wastewater management practice. No reference list has been prepared for this paper, as it has drawn on the content of those papers available at the pre-publication stage of compiling the conference proceedings. However, the lead author (as alphabetically listed in the proceedings' contents) is cited in all cases where reference is made to specific paper content and findings.

2 Primary Treatment Systems

2.1 On-site Compost Systems

Compost toilet systems are generally utilised by well-motivated homeowners who are attracted by what is perceived as an ecological alternative to the flush toilet. Such owners are however relatively few in number, and Davison reports that individual household compost toilet units provide service for only some 0.5% of the total on-site wastewater systems in NSW. Some 250 (20%) out of the State's 1300 compost toilet systems are centred around the Lismore area, thus offering a useful core group for determining owner satisfaction and product compliance with the recent end product standards of AS/NZS 1546.2:2001. It is clear that the overall performance of composting toilet systems is dependent upon the level of user attention to operation and maintenance. User inexperience and poor management are key reasons for poor performance of compost toilet units in the few cases where this occurs. The sampling regime and testing criteria in AS/NZS 1546.2 also appear to have been found wanting. A question that then arises from the Davison findings, is, would users of compost toilets benefit from being tied into a programmed operation, maintenance and monitoring scheme involving regular performance inspections and certification.

One area of investigation into household organic waste management is the application of earthworm-based vermicomposting to process human, kitchen and garden waste together. Panikkar reports that such an approach could have significant benefits in improving sanitation services in the "rural and developing world". However, key to success centres around user education and public awareness of hazard management.

Meanwhile, yet another commercial application of the vermicomposting type has entered the on-site wastewater servicing marketplace. Ames' overview of the *Simply Natural* treatment system indicates it has "novel" features, and is still in the development phase. Limited performance data are available, and much of the paper reads like a commercial brochure. The field performance results of this system will be awaited with interest.

2.2 Septic Tank Design and Performance

Obtaining good design and performance data for household septic tank systems is complicated by the variety of residential occupancy levels and lifestyle influenced water use activities in any one household. How do you design monitoring programmes? Cumming has concentrated on the variation in flow rates to compare with design allowances in past and current standards, while Patterson has "wired up" a group of rural dwellings to get physical data (flow, pH, temperature and conductivity) from their septic tanks. Good design practice is dependent on good design data, and the results of the Cumming and Patterson work are worthy of evaluation as to their ability to contribute to better design practice.

The question of modifying the "conventional" septic tank unit to improve effluent quality continues to be the subject of research. Two university based "experimental" designs have investigated compartmentalised septic tank units incorporating additional biological treatment via anaerobic and aerobic biofilm contact. Khalifé utilised laboratory scale anaerobic/aerobic contact representing two compartments in series (following a septic tank compartment). Mowlaei investigated a three-compartment bench scale pilot anaerobic/aerobic treatment unit. Both found BOD removal rates of up to 80%, promising to relieve the treatment load on land application areas. Of future interest is prototype testing of such modified septic tank systems against the sort of field duty conditions assessed by the work of Cumming and Patterson.

While we await practical developments from the above experimental work, the requirement of effluent outlet filters on all septic tanks is an essential modification in current practice that will ensure restriction of the solids load passing through to the land application system.

2.3 Greywater Treatment

Greywater treatment systems are of particular interest to users of split blackwater (such as compost toilets) and washwater (or greywater) systems. The McCardell research project found good treatment capacity for nutrient and faecal coliform removal in basaltic Chocolate Soil, and suggested that soil beds could be potentially used as tertiary treatment systems for greywater. Gardner's field investigation of sand filter treatment of greywater showed reliable high quality product over 30 months of monitoring. Greywater treatment is of particular interest related to reclamation of water for reuse applications. Gardner notes that at household size treatment units the inefficiency costs indicate that reclamation for reuse is best achieved via community scale treatment operations.

2.4 Additives

The use of "microbiological enhancers" to facilitate treatment processes within on-site wastewater practice has been around for decades, and tends to pit sceptics against advocates. Marketing people make claims for the benefits, while researchers indicate caution in expecting major gains in treatment performance. Vaughan has presented a “marketing” type overview for a specific product, talking up its benefits, while Szymanski has researched another product, indicating its lack of effect on improving septic tank performance. Similar findings on other products from other research are noted. There is no doubt that some of these products have some beneficial effects in some circumstances involving remediation of “failing” systems, but the jury remains out on the benefits of their widespread adoption in future directions for on-site wastewater best practice. The on-site industry should not substitute the use of additives for good design, installation and operation and maintenance.

3 Secondary/Tertiary Treatment Systems

3.1 Aerated Wastewater Treatment Systems (AWTS)

Some councils in New Zealand have concluded that AWTS have no role or a limited role in future directions for on-site wastewater practice because of a clear record of poor or unsatisfactory performance. Manufacturers are very much on the defensive, claiming their products are misused and/or non-maintained. NZWERF (NZ Water Environment Research Foundation) has been given a central government grant to set up an accreditation programme, but many argue that accreditation gives no certainty that field-operating performance will be fully satisfactory. Martin has addressed the gap between accreditation-testing performance and field performance for Australian manufacturers. However, Flapper indicates that NSW accreditation guidelines are part of the problem. The sampling and testing regimes are quite lax in their approach to meeting best management practice. Thus, there would seem to be no substitute for comprehensive field evaluation in assessing reliability and performance consistency of any particular AWTS unit. We have to move beyond a system of accreditation brought in to ensure good design and operation standards of units leaving the factory, and develop a new direction for performance assessment and rating under field operational and loading conditions. It looks like NZWERF will need to tread carefully in this area.

3.2 Sand Filter Treatment

Secondary treatment via sand filter systems following septic tank pre-treatment has become mainstream in NZ, but is only slowly gaining acceptance as an alternative to AWTS in Australia. Many household size on-site systems are installed throughout NZ based on the success of this type of treatment unit in the USA. They are also used in communal treatment systems, and Soar has shown the viability of producing high quality effluent from a village scale recirculating sand filter (70 m^3/day) operating under wide loading fluctuations typical of resort areas. The Waiheke Island (Auckland) plant was commissioned on a design/build/ operate contract, now a common approach to implementing small community sand filter treatment systems in NZ.

Some areas of Australia seem to still be in the trialling phase, although Queensland has successfully installed a large number of one particular type of sand filter unit. Performance assessments of a household size sand filter in NSW are described by Geary, and confirm the technology’s considerable potential to produce high quality effluent. Parkinson found similar results from Tasmanian trials based on Palmer’s successful Queensland designs. Australian regulators should thus be encouraged to put aside their timidity in relying on ‘trials’, and allow a whole range of systems to be installed and performance evaluated under variable household loadings. Sand filters are very robust, and the sooner this is demonstrated by multiple assessments under field conditions the sooner sand filters will be seen as a significant future direction for secondary treatment.

3.3 Natural Systems

Headley has made a useful contribution to the understanding of organic matter and nutrient removal characteristics related to hydraulic detention time in constructed wetlands. Wetland treatment at household scale is attractive to users keen on utilising a 'natural' system to treat domestic effluent. As nature does not necessarily conform to the certainties of mathematical analysis, variable performance on seasonal basis has to be allowed for in wetland applications.

Natural peat has been utilised as a secondary treatment biofilter medium for many years in the USA, and successfully investigated at field scale in NSW as reported and demonstrated by Patterson at past "On-site '99" and "On-site '01" events. Davey is studying peat treatment for nursery runoff, and the results from this over the next year or so should provide further useful information on the potential of peat as a secondary (and tertiary) treatment medium.

3.4 Other Treatment Systems

Research into biofilter kinetics by Xie has shown that attached growth systems perform best at higher temperatures (in the range of 18 to 28 °C). It would be interesting to compare biofilter attached growth performance against activated sludge suspended growth for AWTS units in warmer climate conditions, and to assess their relative merits. Meanwhile, temperature controlled reduction of bacteria in AWTS effluent has been successfully applied as a disinfection process by Vaughan. The process uses heat to lift effluent water temperatures above the tolerance levels for enteric bacteria and viruses.

4 Land Application Systems

4.1 Soil System Performance

The concept of LTAR (long-term-acceptance-rate) in the design of on-site wastewater effluent soil absorption and treatment systems is discussed in the joint AS-NZ standard (AS/NZS 1547:2000 *On-site domestic wastewater management*). Beal has shown that the development of an organic 'biomat' layer on effluent infiltration soil surfaces significantly affects the saturated hydraulic conductivity through the effluent/soil interface. The Beal results confirm US experience in that "a two to three order of magnitude variation in saturated soil hydraulic conductivity collapses to a one order of magnitude variation in LTAR". The observation that DLR (design loading rate) values in AS/NZS 1547 may overestimate soil capacity to accept septic tank effluent in the long term is most interesting, and assessment of field performance of systems sized via the new standard will be of great value in testing this theory. In reality, trench sizes for Australia under AS/NZS 1547 effectively double since DLR values are applied to bottom area sizing, not combined sidewall-bottom area as in the old AS 1547:1994. So, in spite of any mismatch in DLR and LTAR hinted at by Beal, perhaps adequate redundancy is available in newer trench systems to overcome past failure problems. If this redundancy is monitored via programmed operation and maintenance certification inspections, future directions for assessing trench land application performance are secured.

Dawes investigated the physical and chemical characteristics affecting effluent treatment capacity once effluent has moved beyond the infiltrative surfaces within a trench system. Less permeable soils restrict carriage water flow rates thus providing more treatment time. Cation exchange capacity is important (stable soils having Ca:Mg >0.5 are best), and a minimum unsaturated depth of 400mm is required to enable adequate "purification". This later finding will be reassuring to regulatory agencies that set 600mm clearances to water table or restrictive horizons in their rules for on-site wastewater management. Khalil's work on physico-chemical characteristics of soils in southeast Queensland showed significant areas of soils unsuited to renovation of septic tank effluent due to poor nutrient retention capacity. These unsuitable soils were low in cation exchange capacity and low in organic matter content. Clearly, such assessment methods have potential to provide a useful investigative tool in determining on-site wastewater servicing capability in rural-residential development.

4.2 Nitrogen Management

Patterson has raised a question regarding assimilation of nitrogen from on-site systems back into the environment, and asked if requirements for unrealistically large land application areas are based on poor science, or can be justified by risk to public health. His findings are that the current NSW guidelines related to nitrogen management geared to vegetation uptake are flawed. This results in excessive land application areas of such size that they are too large to benefit from the applied nutrients or the carriage water. It is clear that the future direction for best management practice of nitrogen has to move toward development of better and more “appropriate” guidelines.

4.3 Drip Irrigation

The benefits of secondary treated effluent land application via low rate sub-surface drip irrigation systems preface the discussion by Barnes regarding the design and use of a specific dripline product. This is a further “marketing” presentation to conference regarding one of the competing products available for drip irrigation installations. There is no doubt that drip irrigation of high quality effluent has considerable potential to take advantage of the value of effluent nutrients in supporting landscaping development on an individual lot, or for vegetative enhancement of a communal wastewater management site.

5 On-site Wastewater System Management

5.1 Risk Assessment

Powerful investigative tools are now being utilised to assess potential environmental and public health risks associated with on-site wastewater servicing. Whitehead reports on two catchment based studies (Tasmania and NSW) using GIS data set management to enable broad scale assessments of cumulative impacts and outcomes from existing on-site systems. “What if” scenarios for future development patterns or density increases are readily modelled. McGuinness also utilises GIS in highly focused assessments of the potential extent of effluent plumes related to nearly 2000 individual residential on-site wastewater development applications in the Sydney drinking water catchments. The risk assessment system being used in the Hawkesbury Lower Nepean Basin is also discussed by Irvine. Finally, Carroll describes a ‘down-to-earth’ risk assessment procedure for evaluation of the rural residential development potential of land where on-site wastewater servicing is the preferred option. Data from field investigations is subjected to statistical evaluations aimed at correlating selected physical and chemical characteristics of the soils relevant to their capability and suitability in managing effluent to achieve environmental and public health goals.

To an observer, there is clearly merit in being able to assess risks using the methods and data management tools described by the authors. The question arises as to what extent is this risk assessment capacity leading to risk reduction? A useful future direction will be to factor in programmed operation, maintenance & monitoring inspections and performance certification to identify the need for and location of upgrades to remediate malfunctioning systems, and control on-site effluent effects. This can also lead to consideration of options to improve design procedures and methods for new development, and/or to institute off-site decentralised wastewater management schemes where remediation or implementation of improved designs cannot achieve adequate risk reduction levels. Knowing and understanding the risk is the first step in reducing the risk, and these contributions to conference highlight the power of analytical tools in moving towards this ultimate objective.

5.2 The Role of Guidelines/Standards in On-site System Management

An assessment by Austin of consistency in management approach across local government agencies in NSW observes that such consistency is achieved only on a "superficial basis". Two questions then posed are, "does this represent a flaw in the system", and, should this "be viewed as a problem to be addressed by the industry as a whole". In looking at Austin's personal experience of 19 local government areas, it would appear that subsoil and topography drive in large measure individual local government agency approaches to approval of on-site systems. Given the wide range of pre-treatment and land application methods available, some technology preferences dominate in individual areas. On this basis Austin concludes that any "inconsistencies" in relation to use of the various guidelines by differing councils do not represent a "flaw" in the system, but reflect physical and environmental constraints at the local level. This is indeed heartening.

5.3 Programmed Operation, Maintenance and Monitoring Inspections

An important direction for best management practice is programmed operation, maintenance and monitoring inspections and performance certification. AS/NZS 1547:2000 recommends community-wide operation and maintenance monitoring schemes and maintenance certification reports following inspection checks on individual on-site wastewater systems.

The NSW *SepticSafe* programme is the first comprehensive Australian approach to this issue, while the Environment Bay of Plenty (EBOP) "septic tank maintenance programme" is the leading NZ approach. Futter explains that the EBOP programme was driven by the need to address environmental impacts from on-site systems clustered along estuarine and lake foreshores. Three yearly inspections are the basis of the monitoring approach. An important component of such a programme is the "certificate of compliance" database containing the inspection records, and real-estate agents, lawyers and prospective purchasers routinely approach EBOP requesting such certificates before finalising house sales. The EBOP experience has led Futter to the view that centralised management of on-site effluent treatment systems "is the way of the future".

Hill has 15 years wide experience with maintenance contract service reporting on thousands of "advanced on-site systems" in NSW and QLD. Involvement with 84 councils in managing service report information has led Hill to examine the complexities of recording and tracking database information, and advocate the value of setting up a remote monitoring and reporting platform. There is certainly scope for development of effective tools in this area.

Programmed monitoring and maintenance certification inspections are an essential future direction as they provide support for disinterested householders in ensuring proper system oversight. In doing so, they aid in protecting the owner's investment in the treatment and land application system by ensuring that regular maintenance contributes to long life and failure avoidance, and in addition they secure the amenity value of an unsewered locality by achieving high environmental performance from on-site wastewater systems.

6 Environmental Management

6.1 Tracer Monitoring

Geary's work on tracer studies involving dyes and chemical salts has shown the usefulness of lithium chloride and potassium bromide in tracking on-site effluent carriage water plumes in porous soils. Dyes have been found wanting as tracers due to soil particle sorption problems and colour interference from organic matter in groundwater, particularly in estuarine areas. Even colour from household toilet cleansers can show up as interference with tracer dyes.

6.2 Microbiological Assessment

Some significant work is being undertaken on the microbiology related to on-site wastewater management. Charles examined the potential to manage viruses through design and operation of on-site systems, while Linich is working on DNA fingerprinting as an analysis tool in on-site system microbial ecology. Lustig's interest is in microbial transport through soils.

Certainly mention of viruses related to management of on-site wastewater practice gets the attention of politicians and the public. However, quantifiable risk from virus infections relative to well designed operated and maintained on-site systems is likely to be very low. Charles indicates that effective methods related to design and management are available to create a multiple barrier system so as to avoid viral contamination in drinking water catchments. One significant measure advocated is the use of alternating land application areas where spray irrigation of secondary effluent is the predominant land application method.

6.3 Environmental Values and Water

Brennan presents a case that direct or indirect values can be placed upon the various forms of water subject to human use, and introduces the concept of water as an 'eco-currency'. Current environmental assessment processes related to management of water supply and wastewater services do not take into account the complex array of water qualities necessary to achieving an efficient and diverse ecosystem. Clearly, the views presented by Brennan are worthy of evaluation in the context of assessing the resource value of on-site wastewater outputs.

7 Water Reclamation and Reuse

7.1 Greywater as a Resource

The use of greywater as a source of reclaimed water for reuse has been motivated either by the need to reduce wastewater outputs for subsequent on-site management, or to supplement normal supply in water scarce localities or situations. Sorensen has developed a successful NZ greywater reclamation and recycle unit after prototype testing to relieve a failing septic tank effluent soakage trench system in Napier. Reuse through the toilet cistern to reduce wastewater flow has achieved this objective, and now the recycle system is commercially available for similar applications, and for locations where seasonal water shortages can impact on residential water use and impose a need to conserve water.

In Australia a burgeoning population in several areas with water availability constraints has focused regulatory agency attention on the use of greywater as a reclaimed water source. O'Keefe of VIC reviewed country wide interest in this issue, and recommends a nationally consistent approach to addressing the safe on-site use of greywater as a reclaimed water source. Khalifé, also of VIC, reviewed greywater resource use practices in that State, finding many regulatory authorities unwilling to encourage its use, even for garden watering in water short localities, this in spite of State EPA guidelines related to use of greywater as a resource.

With some 50% of household water use potentially available as greywater, then a significant resource is available in water short areas. Greywater diversion for use without pre-treatment is available for direct watering of gardens. Khalifé's survey of Statewide practices has led to the conclusion that practices and regulations are not well settled, and the tendency to "over-regulate" restricts efforts to achieve sustainable wastewater management. Introduction of draft guidelines for "domestic greywater recycling" in WA followed studies and trials related to sustainable water resource management. Priest indicates that public interest in greywater as a resource has led to technical innovations for reclaiming water for reuse for garden irrigation, the most significant use of such water. Demonstration projects may provide the key to promotion of greywater as a practical water resource.

7.2 Case Studies in Reclaimed Water Utilisation

Kele reports on the proposal to provide the 40 separate on-site wastewater systems at a QLD eco-tourism development with water efficient technologies including reclamation and reuse. This includes greywater treatment to supply flush toilet cisterns and wastewater treatment to supply irrigation water for landscape plantings. Xavier outlines a communal management approach for a 40-lot subdivision in northern NSW that centrally collects wastewater for reclamation treatment and recycling for toilet flushing and garden irrigation. Kele also reports on wastewater system studies at a recreation area and a caravan park subject to wide seasonal loading variations, where treated effluent is used for subsurface irrigation of planted beds.

There is significant interest by professionals and the community to make much better use of wastewater as a source of reclaimed water for reuse at the small scale level associated with individual dwellings and communal village type developments. Beavis examined scenarios for alternative delivery of water and wastewater services through a decentralised approach within urban environments and finds that here, as in rural-residential situations, major improvements possible in advancing the sustainability of water and wastewater systems.

8 Observations on Future Directions

On-site '03 has produced a wealth of useful information from a diverse group of talented researchers and on-site wastewater practitioners. Where to now in terms of "future directions for on-site systems – best management practice"? Several key areas stand out.

First, to what extent should all on-site wastewater systems be subject to programmed operation, maintenance, monitoring and performance inspection certification? Second, how should such programmes be designed? Third, what criteria should be used to assess field performance of on-site wastewater secondary treatment units? Fourth, are current nutrient management guidelines really appropriate? Fifth, how can risk assessment methods lead to risk reduction practices? Sixth, what are the research priorities needed to ensure that the most appropriate information is available in achieving future best management practice?

Addressing these questions should not be left to administrative and regulatory agencies. Practitioners in the on-site wastewater management industry should take the initiative in several of these areas, and use the standing of their professional, scientific and industry bodies to advance future best management practice. This could be done, for example, through position papers and industry guidelines. NOSSIG (the National On-site Systems Special Interest Group of AWA) and SWANS-SIG (the Small Wastewater and Natural Systems Special Interest Group of NZWWA) are organisations best placed to set up working groups to address key issues, and then interact with central and local government agencies to ensure that the community at large is provided with effective direction in achieving sustainable solutions for on-site wastewater management.