# ON-SITE WASTEWATER SYSTEMS - RESEARCH, EDUCATION AND TRAINING

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## Abstract

Research dealing with on-site wastewater treatment and disposal in Australia has generally been conducted in an uncoordinated manner over the last 25 years and this continues to be the case today. Lack of adequate funding is partly responsible for this and the transfer of research results into design standards and actual practice has been slow. Education and training programs to assist designers, installers, regulators and managers of on-site wastewater systems also need to be better coordinated between states to overcome many of the current problems in the industry, to improve the performance of individual systems and assist those responsible for managing them.

## Keywords

Education, on-site wastewater systems, research, standards, training

## 1 Research

It is generally accepted that on-site wastewater systems, which rely on soil absorption for effluent treatment, have performed poorly in the past because of hydraulic overloading and an inadequate understanding of the key characteristics of soils. In the United States, where a much larger percentage of the population is unsewered compared to Australia, much of the important research was undertaken during the 1960s and 70s following the post-war suburban expansion when the problems from large numbers of failing systems became evident in newer subdivisions. While we in Australia have been able to learn from this history of research into effluent disposal using soil based systems, one of the difficulties which remains is the ability to transfer research results given that our soils are substantially older and more highly weathered than those in North America. This fact is particularly important in dealing with effluent purification in soils and the use of long-term effluent absorption rates in system design.

Research into the performance of on-site wastewater systems and, in particular, the fate of contaminants from wastewater systems in Australia has been piecemeal and undertaken by only a limited number of individuals and organisations over the last 25 years. In 1983 Brouwer, for example, concluded an extensive literature review by stating that there had been little coordinated effort to look at the problems related to on-site wastewater disposal. Even today, following numerous studies and the introduction of newer technologies, it is difficult to arrive at a vastly different conclusion regarding on-site wastewater research in Australia. In addition to the fact that research is generally still conducted by relatively few, poorly funded individuals and is still uncoordinated in focus, there is still the major concern that research outcomes are rarely implemented and slowly adopted into current practice.

Some 25 years ago the funding provided for on-site wastewater research was initially provided by the major water authorities who were experiencing large numbers of system failures in the rapidly developing outer suburbs in the mid 1970s. If systems failed in small

communities, then there were usually insufficient numbers of people affected to require that the authorities do something about it and, as a consequence, people learned to expect and accept that on-site systems failed. As the local authorities generally had little spare funding to determine what the problems were by conducting the necessary research, there was a reliance on the research outcomes achieved by the larger organizations. Today funding for research dealing with on-site wastewater systems is still difficult to obtain from the established granting bodies, such as the Australian Research Council, and researchers still tend to be relatively few in number.

In looking at the published record in the late 1970s, there was funded research being conducted on both sides of the Australian continent. While the research questions dealing with the sizing of systems and the fate of contaminants being asked were very similar in both locations, the context was very different. In the outer suburbs of Melbourne, concern was being expressed about the hydraulic overloading and poor performance of systems in clay soils (Brouwer, *et al.*, 1979; van de Graaff *et al.*, 1980), as large numbers of problems from failing systems were evident. In Perth however, the concern was related to the large numbers of on-site wastewater systems in the metropolitan area and the rapid movement of effluent through the shallow sandy soils into the groundwater (Parker *et al*., 1979; Carbon and Murray, 1980). Research undertaken at this time and over the following few years led to quite a number of excellent published papers dealing with a many of the issues which we are still discussing today. Examples include the published work on the transformation and fate of nutrients from on-site systems in the vadose zone and shallow groundwaters (Whelan and Barrow, 1984) and the distribution of pathogens both in and below trench systems (Whelan and Parker, 1981). Funding for much of this research was provided by the Commonwealth through the Australian Water Resources Council, the CSIRO, the Water Authority of Western Australia and on occasions, several of the State Government agencies.

Some of the most significant work, which was undertaken during this period and throughout the mid 1980s, was the examination of the clogging layer development and the long-term loading rates, which could be used in the design of soil absorption systems. Both Brouwer and Bugeja (1983) in Victoria and Caldwell Connell Engineers (1986) in Western Australia published work which confirmed what was already known on an ad hoc basis: that there was a clear relationship between a system's total wastewater loading, its performance and therefore its longevity. Systems were failing over time by being hydraulically overloaded once the clogging layer developed. Brouwer and Bugeja (1983) monitored a number of systems and compiled the existing limited data into a possible sizing curve which related the hydraulic conductivity or permeability of the soil and long-term effluent infiltration rate. On the basis of this curve, it became clear that effluent loading rates had to be reduced in soil based absorption systems and effluent disposal areas had to be increased.

In the parallel studies undertaken in Western Australia by Caldwell Connell Engineers (1986), the performance of individual systems was also monitored and a number of failed systems excavated. The failed systems were generally those that were loaded at the highest rates, even in the highly permeable, sandy soils where the development of the clogging layer to a large degree controlled the longer-term infiltrative capacity of the underlying soils. In general terms, soil absorption systems which were loaded at rates between approximately 10 and 20 mm/day ($L/m^2/day$) could be expected to perform satisfactorily independent of soil type, provided the natural soil had a basic adequate permeability. The implications associated with reduced loading rates clearly would mean that lot sizes would also have to be larger in new unsewered subdivisions.

At this time the current Australian Standard (1973), which dealt with the Disposal of Effluent from Small Septic Tanks, offered no guidance with respect to the sizing of disposal areas. In fact the Standard deferred to the local regulatory authority and, while some local authorities prepared their own requirements for effluent disposal, most did not adequately address the issue of on-site effluent disposal in planning or practice. While most Australian states revised their guidelines or codes of practice at some stage during the 1980s (for example, Tasmania, South Australia and Victoria), they generally did not reflect or incorporate the research results, which by now had been peer reviewed and published. The major developments or changes which occurred during this period related to the recognition that a number of specific land capability characteristics were important in assessing the suitability of individual sites for on-site effluent disposal (for example, Rowe *et al*. 1981; Wells, 1987). While this broad scale overview is important where on-site system siting is concerned, there was still very little application of the available research in terms of the design practice associated with the sizing of effluent disposal systems.

The problems with respect to the performance of on-site systems utilizing soil absorption continued to occur in the mid to late 1980s in many parts of Australia and failures were commonly noted, particularly in the subdivisions which were probably going to be sewered when the associated infrastructure was able to catch up. Aerated wastewater treatment (AWT) systems were introduced during this period and a number of Australian states approved their use. They were seen as one of the solutions for problem soils, particularly as there was an opportunity for effluent reuse on-site. Other options such as intermittent sand filters were also permitted in some Australian states, and even peat (Patterson *et al*., 1986) was investigated for its ability to filter and treat domestic wastewaters. Some of the larger authorities also examined various alternative treatment and disposal options, such as sand filters, above ground mounds and shallow placement systems to overcome a number of the identified problems associated with soil based treatment systems as they struggled to provide infrastructure which had been earlier promised to existing subdivisions (Geary, 1988).

Throughout the 1990s, reports continued in relation to the on-going poor performance of soil absorption systems and the resulting environmental concerns regarding additional nutrient and pathogen levels in stormwater runoff and groundwaters. Surveys of system performance in small communities, which were undertaken on either a one off basis (Geary, 1992; Hoxley and Dudding, 1994; Beard *et al*., 1994), or as part of much larger land-use planning studies (Gerritse *et al*., 1990; Gerritse *et al*., 1995), revealed high rates of system failure and the fact that these failures could contribute to declining regional surface and groundwater quality. Sodium as an important issue regarding the longer-term performance of soil absorption systems was also introduced at this time (Patterson, 1993). In NSW, a statewide investigation was undertaken by the Department of Water Resources (O'Neill *et al*., 1993) to examine the impact that on-site effluent disposal systems were having on nutrient levels throughout the state following the highly publicised blue-green algal outbreaks in waterways during the summer months. This comprehensive study involved a site survey of systems in a number of communities and an investigation of land capability criteria, siting, design, performance and awareness of residents. The conclusions with respect to failures were in most cases similar to those from the research undertaken ten years earlier in other parts of the country; that design loading rate is critically important to system performance, that land capability assessment is important, and most importantly, that receiving surface and groundwaters could be compromised by septic runoff in sensitive locations.

In 1994 a revised version of AS1547 was produced by Standards Australia. While it did attempt to redress many of the deficiencies of the 1973 version, there were still a number of

major difficulties with the prescriptive approach outlined. For example, the falling head permeability test was still included, although research years before had shown that it was not necessarily the most appropriate or only way to assess the hydraulic capacity of soil. While this version of the Standard did include reference to some of the research work dealing with long-term effluent absorption rates (the LTAR curve), it did continue with the expectation that a technically exact approach to design and implementation of on-site systems was possible.

Research undertaken by Martens and Warner (1995) at a number of instrumented properties in both sewered and unsewered catchments near Sydney produced considerable evidence of pathogen and nutrient export in stormwater runoff. Both nitrogen and phosphorus exports from septic system catchments were between 50-90 times higher than that in catchments with different effluent disposal practices. Bacterial contamination was also found to be higher in the septic system catchments indicating direct contamination, presumably from surcharging septic trenches in the shallow (<1m) soils. While runoff from these catchments was clearly of poorer quality than runoff from catchments serviced by AWT systems, subsequent work by Khalife and Dharmappa (1996) showed that these systems too could also on occasions perform poorly without appropriate servicing and management. Work by Jelliffe *et al.* (1995) and Gardner *et al*. (1997) at this time raised concerns about the cumulative environmental impacts of large numbers of poorly performing on-site wastewater systems and questions were asked in relation to whether there was a contradiction in terms discussing ecologically sustainable development and on-site wastewater disposal in the same breath. What could be termed the "first" on-site wastewater conference was held in 1996 at Lismore, NSW and many of the mainstream technical issues considered by researchers in the mid 1980s were again debated (Davison, 1996), as well as some research on the newer alternative technologies such as composting toilets and reed beds.

The situation regarding pollution from diffuse sources of runoff was given a topical edge by two incidents in NSW in 1997. Firstly, the highly publicized contamination of Sydney's water supplies by the parasite *Cryptospiridium,* and secondly, a significant public health outbreak associated with oyster contamination. In the latter case at Wallis Lake on the North Coast, approximately 444 people became ill from consuming oysters which had been contaminated by a waterborne *Hepatitis* A virus as a result of contact with human faecal waste. In the investigation which followed, it was concluded that failing on-site wastewater systems were considered likely to have been responsible due to their reported high rates of failure from the large number of unidentified unsewered premises in the catchment. As a consequence of both incidents and the adverse publicity, a number of regulatory reforms were introduced in NSW to enable more effective management of runoff in water supply catchments and in particular, the management of on-site sewage facilities (the *SepticSafe* Program). This program established through the Department of Local Government involved not only the introduction of revised guidelines for the siting and design of on-site wastewater systems (DLG, 1998), but financial assistance in the form of research funding leading to improved performance of on-site wastewater systems and an investigation of alternative options for problem sites. Unfortunately the program of research funding was only of a short-term nature and the hastily revised guidelines prepared in 1998 are now being revised again.

Over these last few years, the issues associated with the under performance of on-site systems and the attendant problems associated with their failure are being treated much more seriously throughout the country and several States have recently re-examined their current regulations and guidelines. AS/NZS 1547 was introduced in 2000 and this has generally been favourably received, with several States actually adopting the performance-based approach it advocates. If anything this document does now reflect some of the piecemeal research which has been

undertaken over many years, but it also shows what we still do not know about the treatment and disposal of on-site wastewater. It is a very conservative document and does acknowledge that the technical approach which was once sought to design is not possible given the nature of our soils and other land capability considerations. Of concern is the fact that research funding is always difficult to obtain and that the things that we learn from research generally take a long time to actually make their way out into practice. It must also be acknowledged that not all research has a practical application. We still need to learn as we go forward and rely on both research and practical knowledge (where appropriate) to ensure that the on-site wastewater systems that we design, install, and regulate perform in an environmentally responsible manner.

## 2 Education and Training

Individuals working in the on-site wastewater field come from many diverse backgrounds with different education and training levels. The designers, installers and regulators must by nature be able to recognize that there is something that they may not know and that it usually requires multidisciplinary skills to work in the on-site wastewater industry, whether it be in site and soil assessment, hydraulic design or plumbing. While people may attempt to learn on the job, be trade qualified through TAFE or have a University degree, it is most unlikely that through this initial training they will have the necessary background to work in this diverse industry. For example, in the tertiary level training for Environmental Health Officers or Environmental Scientists, it may only be possible to cover the basic workings of an on-site system (if that) and there is certainly no coverage of many of the technical and design issues being covered at this and the previous On-site '99 and '01 Conferences. For this reason AS/NZS 1547 (2000) specifies that a number of specific groups in the industry require different levels and components of education and training. While some forms of training are available to different groups in Australia, the level and quality of training varies between States, and the accreditation process associated with particular training programs is in some cases not at all clear.

With respect to tertiary education, all Australian universities provide research training in relation to higher degree programs. Potential students need to have an undergraduate degree and then seek a research supervisor who is working in their field of interest. Only a limited number of tertiary institutions have staff with research interests in the on-site wastewater field and this is partly a reflection of the overall lack of funding available to academics with interests in this area. There have been relatively few research higher degrees completed in the small-scale wastewater field over recent years as a consequence of this.

The TAFE system has developed several short duration training courses in this multi-disciplinary field, however, the content and quality varies significantly between the individual states. Queensland introduced a Domestic Wastewater Treatment Plant Course (CNTIL011) in 1997 and a Site Assessment and Design Course (CNQ12) in 2000 at Yeronga TAFE to meet the requirements of their legislation (Harms, 2001). The Code of Practice for On-site Sewerage Facilities requires that all site evaluators/site assessors have completed an appropriate accredited training program. The Site Assessment and Design Course is an eight day course consisting of site assessment, soil assessment, desk-top study, selection of on-site sewerage facilities and designing and sizing of land application areas. At the moment this is the only accredited course in Queensland and is only available at Yeronga. In NSW an On-site Sewage Management Systems Course (6186) was developed and introduced as one of the initiatives under the *SepticSafe Progam* in 2001 for individuals and organizations involved in servicing, supervision and monitoring on-site sewage systems. The course is conducted as a

short course (block training program) over nine days and consists of five modules including occupational health and safety, on-site sewage management, testing and monitoring, sewage treatment and quality assurance. TAFE NSW state that the course is relevant to AWT system service providers, plumbers and septic pumpers engaged in servicing septic systems or seeking accreditation with local Councils for the purpose of third party accreditation. The promotional information claims that the course is suitable for landowners seeking to service their own systems if permitted by Council. The course has now been offered on several occasions, following a pilot run at Bankstown in 2002, at different NSW TAFE Institutes, however, concerns have been expressed at the little practical/field component and the notable absence of site and soil assessment. Enrolment numbers have typically been low and unfavourable reports have been received from some of those attending. It is understood that development work on a similar, yet separate course to be offered externally by Holmesglen TAFE is underway in Victoria.

An industry based training course for the servicing of domestic AWT systems was established in 1998 in response to a request from the Manufacturers' Association (although not all manufacturers are members of this association). Surveys by local Councils and NSW Health had previously found that a lack of maintenance was contributing to a high failure rate of this type of system. The course was developed to provide a baseline for training of maintenance contractors and a benchmark against which local Councils could assure the quality of service contractors operating in their own local government areas. In 1999 the first pilot course was conducted and VETAB accreditation was obtained. It is a training course specifically aimed at maintenance contractors servicing domestic aerated wastewater treatment systems and has been conducted on several occasions. The course is of three days duration and includes classroom work (two days) and time visiting a working STP and examining AWT systems (one day).

Between 1994 and 1996 the University of Newcastle, NSW through its Department of Community Programs organized nine one and two-day seminars where many matters relevant to on-site wastewater training were covered. From these seminars, the service provider Centre for Environmental Training (CET) developed a three day training course which, since early 1997, has now been offered at various venues in each Australian state and in New Zealand on thirty occasions to over 1500 people. Their On-site Wastewater Management Training Course which has a broad perspective and national focus has filled the obvious training need vacuum which existing in the late 1990's. Many people currently working in the industry have attended these training courses which aim to provide a thorough background in site and soil assessment issues, as well as coverage of basic system design principles (Geary *et al.*, 1999). The offerings of CET have in recent years expanded to cover, in particular Site and Soil Reports, and more advanced topics such as Sand Filters and Package Treatment Plants.

## 3 Conclusions

Some of the research that has been undertaken in Australia dealing with aspects of on-site wastewater treatment and disposal over the last 25 years has been of a very high standard and contributed to the international literature. There have however been insufficient resources and funding directed towards research and this trend continues today. This is partly a reflection of our urban priorities as a nation and it also reflects the fragmented and decentralized nature of our industry. While it is possible to say that we have benefited from the research that has been undertaken (in that we are now more aware of what the issues are and our various design codes have been modified to reflect this), it is difficult to directly follow the path that led us here. Research is important because it does contribute to practical advancement and this is the

case with on-site wastewater research, however, it appears as though we have been slow to adapt in some cases and are still keen to repeat some of the things which were done years ago and which have not served us well.

On the basis of the training courses mentioned, and particularly since the introduction of AS/NZS 1547 in 2000, it is clear that within Australia there is a need for on-site system wastewater training. It needs to be developed at an appropriate level for all players in the industry and there are clearly a number of different training opportunities as new people enter the industry. One of the difficulties still relates to defining who is being trained to do what, whether accreditation is required and just what the requirements of the particular relevant authority are. As in Australia, on-site wastewater disposal in the United States is regulated by each individual State and the State decides on the relevant training required by each individual. The training that is required depends on the scope of work undertaken, that is, whether the individual is an installer, designer or regulator of on-site systems. If the person undertakes site assessment and then designs the system, then there is a clear requirement that they be trained in those specific areas. Perhaps we need to clearly specify roles similar to these and then decide on the relevant accreditation procedures. Training requirements need to be clarified by each State so that there is some uniformity in this particular area.

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