Sustainable On-Site Domestic Wastewater Management

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"This century has been by far the most remarkable, in the intellectual history of the world, for its great progress in scientific discovery and invention. But in the midst of all the beneficial inventions made during the period, there is one which is wholly evil – I mean the water closet"

This was written by Charles Richardson, a nineteenth-century engineer. His point was that in depositing our human wastes into water, we were turning a small problem into a large one. The aim of on-site wastewater designers is to make human waste a small problem again, and we feel ecological architects have a definite role to play in making this come true.

Treatment of human waste

When we are using a water closet to contemplate the problems of the world, our urine and faeces drop into water, so that they are cut off from air. This means that the only bacteria that can digest our wastes are what are described as **anaerobic**. They produce H_2S (rotten egg gas), NH_3 (ammonia) and CH_4 (methane). This is why sewers don't smell very nice.

If our faeces were in air, they could be treated by **aerobic** bacteria which produce instead SO_x (sulphur oxides), NO_x (nitrogen oxides) and CO_2. They do not smell and are not as harmful for the environment.

Centralised Sewage

Because of this, wastewater engineers spend lots of money and use great quantities of energy trying to get the air back into the wastewater in a conventional centralised sewage system. This is pretty tricky and therefore technically very challenging. They use trickling filters, activated sludge chambers, sand filters, Pasveer Channels, sequencing batch aerators, all wonderfully technical equipment. So wastewater engineers don't mind if you continue to use water closets at all. That's what they are trained to do – solve technical problems.

What they don't do very often, is ask why put our faeces into water in the first place? The answer is that such airy-fairy questions are for lesser mortals, such as architects.

All this has been a long way around telling you what you now know. The key to successful wastewater management is not the water, it's the air. You can stop reading this article now. The rest of it will just be elaboration.

On-Site Systems

On-site systems are those systems that collect and treat wastewater on the same site where it is produced.

Removal of solids

On-site systems all have at the front end some equipment for removing the solids. Usually, this is a septic tank. In its simplest form, this is a chamber where the effluent is stored for at least 24 hours, so that the solids can settle out and the grease, oil and fat can float to the surface.

The septic tank can be much more elaborate. It can have 2 or more chambers; it can have baffles at the inlets and outlets to stop the scum passing through to the next stage; it can have filters; and it can have special shapes to help trap even more of the solids. Each design is better than the next – just ask the manufacturers.

Treatment of effluent

In the next stage, the effluent might pass into a trench and from there into the soil. As it travels down through the soil, it passes bacteria, protozoa and other organisms living on the soil particles and feeding on the nutrients in the effluent. The effluent has nitrogen in it, from the urine and other wastes. There are special bacteria and other organisms which feed on the nitrogen compounds, and the more nitrogen in the effluent, the more they grow and multiply. If this is happening in a trench in the soil, they can grow so much that they fill up the pores in the soil and stop the air getting in. The trench becomes clogged and the effluent rises to the surface, and the garden acquires a lush green strip of grass, or worse.

The trick is to make sure the effluent is spread over a large enough area, so that the pores can still have air in them. If the soil is a nice sandy loam, this shouldn't be too much of a problem. But, if the soil is a heavy clay, the permeability will be low, and a lot more trench would be needed to allow the effluent to drain away very slowly, when the pores are already filled. Another problem we can encounter on a site is when the watertable is close to the surface, so that the air is excluded.

There are several strategies for coping with low-permeability soils and soils with a high watertable.

- We could put a mound of good soil on top, with the trench or trenches in the mound (*Figure 1*). The effluent percolates from the trenches through the soil in the mound and is treated by the time it reaches the natural surface.
- We could run the effluent through a sub-surface irrigation system. The soil near the surface should still be quite porous, because the roots of plants, the worms and other organisms help keep the topsoil aerated and porous.
- We could plant shrubs, reeds and grasses to evapotranspire some or all of the effluent.
- We could run the effluent from the septic tank through a reed bed to remove more of the solids, some or all of the nutrients (nitrogen and phosphorus) in the soil and some or all of the liquid (*Figure 2*).

Blackwater and greywater

We could also separate the 'blackwater' from the 'greywater'. The wastewater which comes from a water closet is called blackwater. The other wastes which a household generates from the kitchen, the bathroom and the laundry, together are called greywater.

If the greywater is treated separately from the blackwater, the length of the trench can be 3 or 4 times less than for combined wastewater. This suggests to us that we might try to avoid putting our toilet wastes into the wastewater.

Composting toilets

One way of doing this is to use composting toilets. There are lots of models of composting toilets, but they all work according to the principles shown in *Figure 3*.

The faeces are deposited in a sealed chamber which has air circulating slowly through it. The odours are extracted up a vent (there will still be some anaerobic bacteria present), and the material stays in the chamber until it is fully composted. The material shrinks to about a quarter of its size or less, and the compost can be used in the garden as a soil conditioner.

Energy

I have mentioned that conventional centralised sewerage systems use a lot of energy. With our on-site systems, we try to make designs which use hardly any grid power – or even none at all.

Most of our energy to run our on-site systems comes from the environment. We try to make our flows run by gravity, to have (sun-powered) plants taking up the effluent, and to have natural organisms in the soil acquire the energy to grow and multiply by consuming the nutrients in the effluent.

Problems?

All this seems straightforward. Why then, have septic-tank systems not worked?

Well actually, a lot of them have worked, but this does not hide the fact that too many have not. There are three main reasons for this.

The first is that the system can be badly designed. The septic tank can be too small. The trenches can be too short. The trenches may not even be level – this is important for distributing the effluent widely, otherwise it can be concentrated at just one end and drown out the pores in the soil.

The second main reason is that the systems are not installed properly. Even if the design is satisfactory there are many plumbers who look at a design and know they know better. For this reason, the new Standard will specify that the installation will need to be certified as being in accordance with the design.

The third main reason is that the system is not maintained properly. Until recently, councils hardly ever checked if people were looking after their on-site systems. With the new regulations in NSW, this will change on 1 July, when councils will require householders to have their systems certified as being looked after properly. This is what is done in the USA, where 30 to 40% of the population uses an on-site system, compared to 10% here. We might expect there will be fewer failures than we get now.

Ecological architects and on-site wastewater

How might ecological architects help foster sustainable on-site wastewater management? Actually, it's dead easy. All you have to do is call in a suitably qualified on-site designer early, preferably during the formulation of your design, so that the sustainability of the design is maximised. For instance, you would rather find out sooner than later that the exquisite site at the water's edge is a little bit too far down the hill for a wastewater system, and if kept there would mean pumping effluent uphill to the treatment area – for ever.

Wastewater design may seem a bit mundane, and merely a matter of a few pipes here and there. But please remember, we are trying to get the environment to treat the material instead of using expensive equipment, energy and chemicals. That means we need to be careful to make sure we have put the land-application area on the downhill area on the downhill side, well away from any watercourse, open to the sun or accessible for evapotranspiration by the surrounding vegetation, and well above the watertable just for starters.

Ecological architects are trained to combine a range of resources, operate within a plethora of constraints, get good cooperation from a host of consultants, tradespeople and designers, make the client happy and still produce something which is beautiful and which harmonises with the environment.

We, as on-site wastewater managers, would be only too pleased to work with ecological architects, as the treatment of wastewater is an essential part of any sustainable ecological design.