BOTANICAL WASTEWATER TREATMENT SYSTEMS – WETLANDS FOR ON-SITE DOMESTIC WASTEWATER MANAGEMENT

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ABSTRACT

The Botanical Wastewater Treatment System for on-site domestic wastewater management was patented in NZ in 1997. Its concept is well proven by experience in Germany with over 300 wastewater wetland systems installed from 1988 until introduced to NZ. Since 1997 the author has had a range of experience in having the system accepted by local authorities. The performance of local systems indicates it can achieve a high quality secondary effluent. Siting and sizing guidelines are presented along with potential applications and limitations for use of the wetland system. These are discussed in the context of four NZ case studies, including an outline of the construction and planting process, commissioning and maintenance requirements. Effective wastewater servicing can be achieved by giving the owner responsibility for what is a sustainable garden feature with basic maintenance requirements and zero to low energy use

KEYWORDS

Botanical wastewater treatment; on-site wastewater wetland

1 GERMAN EXPERIENCE

Dr. Kaethe Seidel and landscaper Fridolin Rausch started in 1976 with the first wastewater wetland system and grew it to 21 systems. The author was involved from 1988 in taking it to a new level with a CAD system. Up until he moved to NZ in 1997 some 300 Botanical Wastewater Treatment Systems were built.

Further applications for the technology came in 1994/95 with a Stage Two for 20 PE (population equivalent) on top of an office/housekeeper bungalow with a wetland roof garden. Another was installed on a building roof as a cooling device for an apple juice factory. Further projects involved Stage One as a sludge dewatering facility for pump-out liquid from septic tanks and on a big scale for sludge from a mechanical plant for 30,000 PE.

Around 60 % of the systems built were Type 3 wetlands. These comprise a pump sump with a macerator pump only, the raw wastewater being dispersed over the surface of Stage One. The Type 3 wetland has the advantage of having no odorous septic system and no more tank pump-outs. Instead, with full circle treatment on-site, after around 20 years some 3m³ of best quality compost soil is available for the garden – from a 5 PE system.

2 NEW ZEALAND EXPERIENCE

Key elements in the New Zealand experience are as follows:

- December 1997 – NZ Patent 329455 granted for the Botanical Wastewater Treatment System (BTWS).
- December 1998 – Auckland City Council had a look at the documentation and decided to give a one off consent for a single household 5 PE system on a 1000m² lot in Palm Beach/Waiheke Island.(System A)
- December 1999 – Palm Beach system fully commissioned and is still in operation. In the same year all the available data was presented to the ARC, via Water Quality Scientist Robert van Duivenboden from the Resource Quality Section.
- 2003/4 – It was a longer process to get Resource Consent for another system on Waiheke. Since 2005 this wetland for 5PE has been working successfully in Palm Beach.(System B)
- 2005 – Another extended Resource Consent process resulted in approval for a system on 8.8 ha in Clevedon.

3 BWTS PERFORMANCE

Treated effluent from two BWTS on Waiheke Island has been sampled for BOD_5 and TSS over the years, System A since January 2000, and System B since November 2005. Test results for samples from the Stage Two effluent discharge outlet are:

System	BOD_5 (mean)	TSS (mean)
A	5.1 g/m^3	9 g/m^3
B	0.3 g/m^3	2.25 g/m^3

In addition System B was tested by Watercare in 2007 for TN (total nitrogen). Sampling was undertaken at three different places. Test results show the following:

- Inlet into the system (raw wastewater) 122 g/m^3 TN.
- After Stage One 84 g/m^3 TN.
- Stage Two after 20% of the 'way' towards the outlet 30 g/m^3 TN.

4 SITING

Wetland systems should be exposed to the sun, not placed under drip lines of trees, and new plantings should not create potential for disturbing the operation of the BWTS through shading or root development. Any existing or potential surface water impacts have to be avoided and proper measures put in place to divert water via swales, and/or cut off drains from surface flow as well as overflows from tanks/gutters/spouting. Run off from council road reserves should by-pass the property.

Optimal siting will reflect a comprehensive site assessment and integrated storm water management.

5 SIZING

The BWTS is currently used only for the secondary treatment of all-wastes domestic wastewater (blackwater and greywater combined). Design flow and raw wastewater quality is based on 150L/person/day and 60g of BOD_5/person/day.

The performance results achieved are based on a two stage treatment process sized at $5m^2$/person total surface area ($2m^2$/person Stage 1 and $3m^2$/person Stage 2) and a HRT (Hydraulic Retention Time) of 2.3 days at normal operating depth of 200mm and 3.5 days at full media depth of 300mm. For separated systems a reduction in area of 40% is recommended for treating greywater alone. Adopting a conservative approach, the same reduction is advised for blackwater only.

Note that the design criteria above apply to systems installed in the climate conditions of Northland, Auckland and Coromandel. For cooler climate conditions more conservative design criteria are used. Where tertiary treatment of domestic wastewater is required (such as nitrogen reduction) a longer retention time involving a further treatment stage is required.

No reduction in the sizing of the system is made for the benefits of evapo-transpiration via the plants or evaporation from the surface of the filter media. Evapo-transpiration losses to atmosphere can be quite significant under warm water and summer conditions, but are treated as an operational factor of safety.

6 EXAMPLES

The first BTWS was constructed in 1999. It is the so called Compact Type, three basins in one for 4-5 people and is located on Waiheke Island (System A).

The second is at an undisclosed NZ location (2004) for 8 people on a small block of land.

The third is an ARC consented system again on Waiheke Island, sized for 4-5 people and built in 2005 (System B).

Example four is in Coromandel Township at the Driving Creek Railway and Pottery, and is capable of dealing with the wastewater from 6 – 8 people in residence and up to 400 to 500 visitors daily in the peak months December to January. It was built in February/March 2009. The system handles up to 60,000 visitors per year.

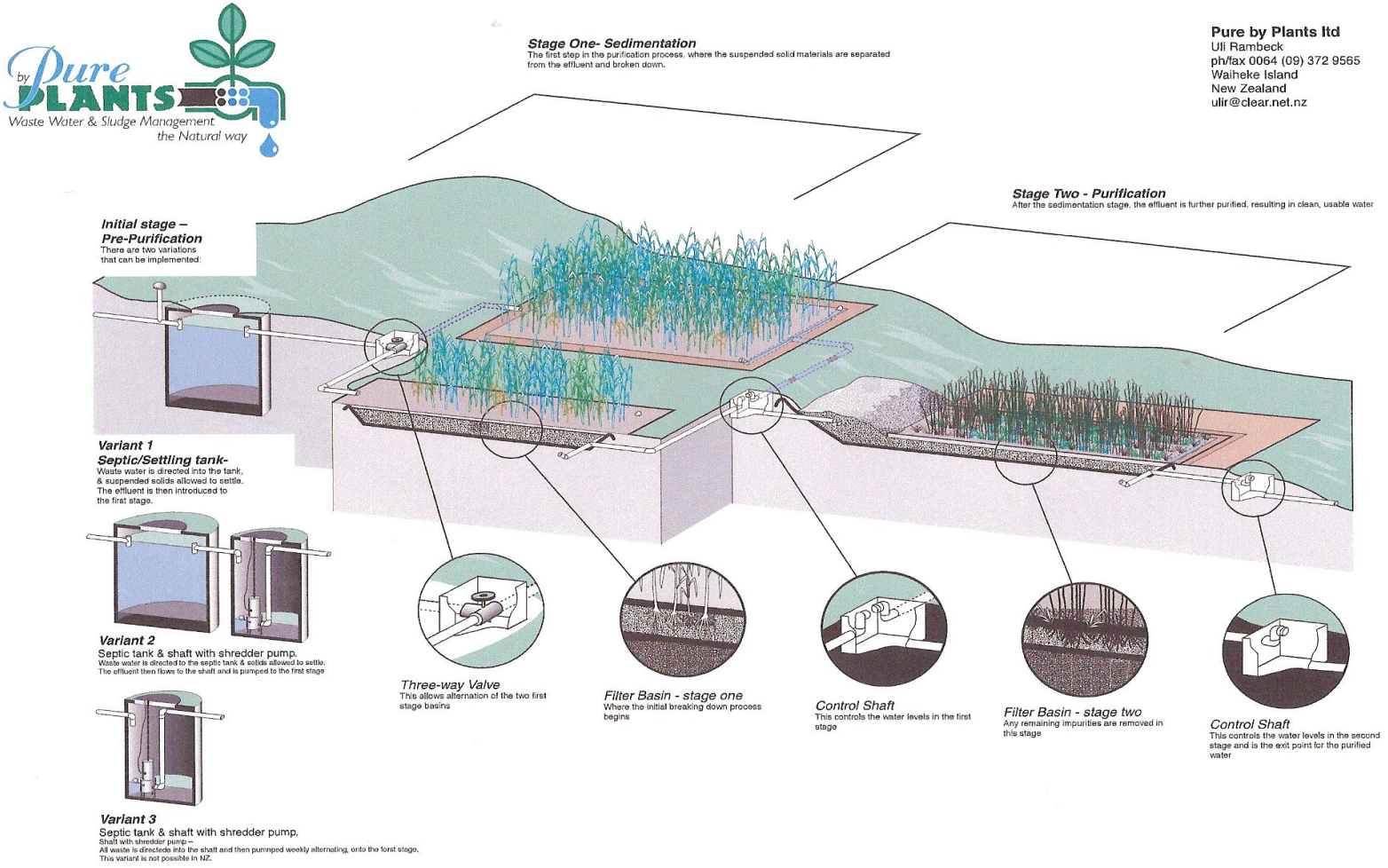
7 CONSTRUCTION

The typical configuration comprises a parallel twin basin first stage in series with a single basin second stage (Figure 1). For a number of customers the Compact Type, all two stages on one basin, can be used. However, configuration can be modified as required to suit site conditions. In addition, two-pass staged systems in series or single pass (one or more systems in parallel) can be offered, to cater for all needs.

Stage One and Stage Two are sealed against the underground subsoil with a liner. Liner options include:

- EPDM Geomembrane (“rubber”, market leader Firestone). It has the best uv resistance – lasts 30 plus years fully exposed to full sun. The temperature gauge can vary between -35^{o} and $+80^{o}$ Celsius. It is the best liner under ecological considerations, but the most expensive.
- FPO Liner (Flexible Polyolefine), a product without Halogenes (e.g. chlorides or bromides) and heavy metals, available with or without reinforcing polyester wire-mesh. It is similar in quality to EPDM, but not so eco friendly. It is also less expensive than EPDM.
- uPVC – P (Poly Vinyl Chloride). It has medium uv resistance and is produced with special chemicals to be and to stay soft. It has a temperature tolerance down to -35^{o} Celsius and as far as is known up to $+60^{o}$ Celsius. The life expectancy for fully exposed liners is 25 years. uPVC gets used for fish ponds and is now more acceptable from an environmental point of view. It is widely used and the cheapest option of all three liners suitable for wetland systems

Figure 1: *Botanical Wastewater Treatment System Schematic*



The composition of the filter media is gravel and filter sand. The gravel media consists of three layers, each 100 mm thick as follows:

- coarse at the bottom – 40/60mm
- medium in the middle – 20/40mm
- finer at the top – 10/20mm

For Stage One the gravel filter media is covered with a 100mm layer of filter sand.

Stage One and Stage Two will be planted with 3 to 5 plants per square metre. The following plants are recommended and chosen for their performance under the different climatic regimes in NZ:

Baumea articulata; Eleocharis sphaceelata; Typha orientalis; Juncus gregiflorus; Cyperus involcratus; Carex fascicularis; Schoenoplectus validus

8 COMMISSIONING

Initially the water level below the surface of the filter media is held at 50mm to 100mm until the plants are well established, then decreased to around 150 mm under the surface. Stage One and Stage Two of the BWTS have to be filled with clean water after construction completion and prior to receiving septic tank effluent. Design treatment performance levels will be reached for a completely new system within some 6 to 8 weeks. For a system with an already existing septic tank or mechanical treatment system where the BWTS is installed as an upgrade/add on, performance levels will be reached in some 4 to 6 weeks.

9 GUIDELINES AND MAINTENANCE

For the different regions in New Zealand local drainage companies undertake BWTS construction and also carry out maintenance inspections as required. However, homeowners are provided with a user guidelines and maintenance manual, and once plantings have become well established are readily able to maintain the BWTS themselves as a garden feature.

9.1 WATER LEVELS

- Initially the water level below the surface of the filter media is 50-100mm until plants are well established, then at around 150mm under.
- In future, if the residents leave the property e.g. during summer holidays (Nov-April), the water levels need to be raised to the top of the filter media – achieved by adjusting the outlet pipe in the control shaft at the outlet of the respective stage.

9.2 VEGETATION

- No trees/shrubs are to be planted around the system to ensure optimum light and growth conditions for the wetland plants.
- Plant composition will change over time – some plants will grow rapidly and certain weeds will establish.
- Weeds are to be removed and vigorous plants are to be cut at ground level.
- If plants are affected by bad weather e.g. blown over in severe winds, they should be cut back to 200-500mm.
- Plant cuttings are to be put onto the garden compost pile or taken to the transfer station.
- Ensure a grassed area about 1m wide is kept around the edge of both stages for ease of access and maintenance.

- Plants are to be cut back annually to 200-300mm during July/August. In frost prone areas e.g. South Island, cuttings can be left on top of the system and then removed with other 'dead growth' during mid-Spring.

9.3 SECURITY

- Avoid stepping on the filter media surface.
- If necessary keep domestic animals or wild animals/birds (e.g. pukekos) off the system by covering with netting or erecting appropriate fencing.
- Children are to be told not to play in the area, otherwise the system should be fenced off (paddock fencing will suffice).

9.4 EXCESS WATER

- Ensure no surface water, other drainage or well water enters the system. It is only designed for domestic wastewater.

9.5 MAINTENANCE CONTRACT

For a BWTS without any mechanical component (i.e. a pump) a minimum of two short inspection and maintenance visits from the local drainage company per year will be required, with particular attention to the primary treatment elements (e.g. septic tank and outlet filters).

During the walk over inspection all installations can be checked together with the person responsible (homeowner/occupier), work to be done pointed out and questions answered.

It is at the owner's discretion to delegate the maintenance and inspection program (as per the inspection records sheet to the drainage company. For many owners, taking on the responsibility for inspections is not too difficult – others may prefer to leave this to trained service personnel.

The pump shaft and pump should be washed with a water blaster (or similar) 4 to 5 times per year.

10 CONCLUSION

The Botanical Wastewater Treatment System is a constructed wetland for providing on-site secondary treatment of domestic wastewater. Its construction involves gravity through flow which enables high quality effluent to be produced with zero energy input. The easily maintained planted layout provides a sustainable garden feature for any property where size and site conditions are favourable.