TAKING THE 'WASTE' OUT OF WASTEWATER WITH *OZZI KLEEN*

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Abstract

We are becoming increasingly aware that in the near future it will not be gold or oil that is considered our most precious resource – but water. As the value of water continues to increase, *Ozzi Kleen* aims to provide the highest possible effluent, in order to maximise re-use.

Ozzi Kleen is a domestic size sewage system using a tried and proven treatment method associated with modern city and town treatment plants – the activated sludge process. This technology is unequalled by any other domestic treatment plant available – it allows the end user the convenience of town sewage while maintaining public health and a sustainable environment. *Ozzi Kleen* treats sewage as a resource, not a waste.

Since the prototype in 1990, *Ozzi Kleen* has been continually upgraded and improved. The latest addition to the *Ozzi Kleen* range is phosphorus and nitrogen removal.

Keywords

activated sludge, reuse,

1 History

After 22 years in the wastewater industry, starting as a chemist in a sugar mill then as principal manager and overseer of all sewage treatment plants in the Maroochy Shire Council, (Sunshine Coast), the author was convinced of the need for a better way to treat household waste (without the convenience of town sewage). From this knowledge, a new concept in household sewage treatment systems was developed based on the cyclic extended aeration activated sludge sewage treatment process. This technology, in a domestic application, is unique to *Ozzi Kleen*.

A considerable amount of treated water from the council owned sewage treatment plants goes to waste. It seems strange that we go to all the trouble to properly treat wastewater, only to discharge it without further consideration towards reuse.

2 Reuse Opportunities

The theme of the *Effluent Reuse Conference*, Wollongong University (mid 80s) was to change the attitudes and direction of the industry from 'effluent disposal' to 'effluent reuse'. Disposal means to get rid of, reuse means to dispose of where it can be reused at some value more than once. Water is a premium resource, this rapid recognition, is providing a challenge for the wastewater industry.

3 Experimentation

3.1 Step 1

Experimentation with wastewater treatment began in 1988, from where the first mini activated sludge system using 'cyclic extended aeration' was designed and built, a process similar to that carried out by council owned systems.

The system was connected to a private dwelling with six adults, and worked very well for two years. The plant was monitored using the council laboratory for BOD and NFR. Test results are shown in Table 1.

TABLE 1. Test Results of Home Grown *Ozzi Kleen*, April 1991

CONSTITUENTS	SECONDARY EFFLUENT (MG/L) APRIL 1991 - DAY				
	10	**14**	**15**	**19**	**20**
Biochemical Oxygen Demand (BOD)	15	11	19	12	18
Total suspended solids (TSS) (formerly NFR)	21	22	29	25	18
Thermo tolerant Coliform (org/100ml) (TC)	10	70	100	100	10

3.2 Step 2

After some consideration the tank was redesigned, approval sought, and the product marketed. The system was designed for the market place. In the design, five main features were provided for total convenience of the end user.

- A treatment process that was reliable and simple in its operation
- Unaffected by household cleaners and disinfectants
- Able to cope with heavy shock loads
- A system that is easy to install, using lightweight equipment
- A system that has very few parts and equipment in contact with the waste, minimising potential malfunctions

The first of the new treatment system tanks were manufactured from fibreglass, layered with a handheld chopper gun in the shape of a sphere. This was an excellent design idea but was difficult to transport and install, lacking quality control in the manufacture. The tank eventually failed, mainly because the wall thickness at the point of fracture was only 2 mm thick instead of the proposed 6 mm, as according to the design.

3.3 Step 3

The dimensions and sizing of the components from the fibreglass tank were transferred to the new designed tank. This new tank was fabricated in marine grade aluminium. It was from this system that the appropriate water samples were taken as part of the testing for approvals, from the Queensland Water Resources Commission, in 1993 for the Model No AL4600. Test results carried out by the Australian Laboratory Services are given in Table 2. Despite their good results, aluminium tanks are uneconomic to make.

TABLE 2. Test Results of *Ozzi Kleen* AL4600

CONSTITUENTS	RESULTS – EFFLUENT (mg/L)													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Suspended solids	8	<1	16	20	20	22	26	14	22	14	19	20	22	15
Free chlorine	3.0	2.0	0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
Biochemical oxygen demand	2	2	14	14	19	9	16	17	23	2	1	10	20	12

3.4 Step 4

After extensive research Roto-moulded polyethylene tanks were chosen, for several reasons:

- Light weight
- Stronger than concrete (weight for weight)
- Will not crack
- Stronger than injection moulding

Polyethylene tanks have proven to be very successful in all weather conditions, from the snow in the Tasmanian Highlands to the Dinosaur National Park in outback West Queensland, with over 2 500 of these tanks currently installed in and above ground.

Figure 1 ***Ozzi Kleen*** **Current Polyethylene Tank**

Diameter	1.95 m
Wall Height	1.9 m
Overall Height	2.35 m
Weight	350 kg
Thickness	up to 18 mm

Polyethylene Tank Specifications as at June 2001

4. The Success of the Activated Sludge Treatment Process

The process utilised in *Ozzi Kleen* is activated sludge. *Ozzi Kleen* systems do not use a septic or anaerobic section as a primary or secondary process. The system is fully aerobic where the waste enters the aeration compartment via a stilling well where aeration and oxidation of the waste occurs in a single basin. The activated sludge treatment process achieves effective and efficient treatment with no compromise of the end users' convenience.

4.1 Copes with Shock Loading and Extreme Loading

This activated sludge process has a high resistance to shock loading and extreme overloading. For example, the Nambour Sewage Treatment Plant serves a town of approximately 8000 EP (equivalent persons), including one of the largest regional hospitals outside of Brisbane and a large milk factory. Before augmentation work (late 80s) this plant was 50% overloaded and yet was still performing satisfactorily. Another example of extreme overloading was an *Ozzi Kleen* system installed in 1992 for White Mining, North Queensland. This plant was originally a 400 EP system serving 780 persons at the White Mining construction camp and still producing the required standard of effluent.

4.1 No Restrictions on Household Cleaners, Disinfectants and Bleaches

Another advantage of the activated sludge treatment process is its ability to cope with extra-strength cleaners, disinfectants, and bleaches, which destroy anaerobic bacteria, but do not harm aerobic bacteria, found in the activated sludge process.

5 Advanced Secondary Effluent

In the late 90s, the Queensland Department of Natural Resources introduced the *Interim Code of Practice* for the on-site sewerage industry, where it indicated a third level of treated effluent – advanced secondary effluent. Various effluent criteria are compared in Table 3.

TABLE 3. Advanced Secondary Effluent Treatment Criteria

CONSTITUENTS	PRIMARY EFFLUENT (mg/L)	SECONDARY EFFLUENT (mg/L)	ADVANCED SECONDARY EFFLUENT (mg/L)
Biochemical oxygen demand (BOD)	120-240	$\leq$ 20	$\leq$ 10
Suspended solids (SS)	65-180	$\leq$ 30	$\leq$ 10
Total nitrogen (TN)	36-45	$\leq$ 30	$\leq$ 10
Total phosphorus (TP)	6-10	$\leq$ 10	$\leq$ 5
Thermo tolerant coliforms (org/100ml)		$\leq$ 200	$\leq$ 10

5.1 The Step from Secondary to Advanced Secondary

The advanced secondary effluent criteria posed a challenge the *Ozzi Kleen*. Over the years of council monitoring of domestic onsite systems throughout the Maroochy Shire, the standard *Ozzi Kleen* showed moderately consistent test results of TKN of < 5mg/L with many results as low as 1mg/L. Readings were as low as pH 4, indicating some denitrification. Results of tests carried out by the Australian Laboratory Services are shown in Table 4. With the activated sludge process, nitrification is rather easy to achieve. With an improved aeration system, nitrification was more reliable using lower air volumes and reduced aeration.

TABLE 4. *Ozzi Kleen* Secondary Effluent Achieved in the Field

REGISTER NO & LOCATION	DATE OF SAMPLE	FREE CHLORINE RESIDUAL (mg/L)	pH	AMMONIA NITROGEN (mg/L)	NFR (mg/L)	BOD5 (mg/L)	FAECAL COLIFORMS (PER 100 mL)
SHSTP371 Peregian Beach	23/06/97	0.2	6.1	6	28	19	60
SHSTP360 Maroochy River	24/06/97	<0.1	6.6	1	25	16	8800
SHSTP362 Maroochy River	24/06/97	0.3	6.7	1	25	14	30
SHSTP358 Kureelpa	30/06/97	0.1	7.4	1	17	4	900
SHSTP296 Verrierdale	23/06/97	0.2	6.5	1	17	2	10
SHSTP324 Flaxton	01/07/97	0.2	3.3	1	15	2	10

5.1.1 Aeration Levels

Oxygen conditions in the treatment plant must be controlled properly for biological removal of carbonaceous and nitrogenous wastes to occur. For carbon removal and conversion of ammonia to nitrate, aerobic conditions with dissolved oxygen (DO) concentrations of 1–2 mg/L must be maintained. Conversion of nitrate to nitrogenous gases requires anoxic conditions with DO levels below 0.2 mg/L. The operator must be able to determine whether conditions in the plant are aerobic or anoxic. Although DO meters may be used, they are expensive, require daily calibration, and are inaccurate at very low DO levels.

Many package plant operators already have electronic pH meters, because these are required for compliance with certain regulations. Most pH meters have a pH scale and millivolt (mV) scale. The oxidation-reduction potential (ORP) probe uses the mV scale. ORP measures the relative amount of oxidized versus reduced materials in the system, or the capacity of the activated sludge to gain or release electrons. By checking ORP values, an operator at a small treatment facility can determine whether oxygen and nitrates are available as electron acceptors (aerobic conditions); whether nitrate is available but free DO is unavailable as an electron acceptor (anoxic conditions); or whether neither nitrate nor oxygen are available as an electron acceptor (anaerobic conditions).

For process control purposes, this type of information is far more valuable to the operator than a DO value. It can be used to determine whether systems or parts of systems are within proper ranges for organic carbon oxidation, nitrification, denitrification, and anaerobic fermentation.

ORP readings between 50 and –50 mV indicate anoxic conditions, while an ORP between 50 and 300 mV indicates aerobic conditions (see table 5, Oxidation-reduction Potential and Metabolic Processes). ORP and combined ORP-pH probes are available for less than $200. In addition, reference solutions are available to indicate whether a probe is operating correctly. The tests can be conducted onsite, are as simple to run as a pH test, and take only minutes to perform.

TABLE 5. Oxidation-Reduction Potential and Metabolic Processes

Oxidation-Reduction Potential and Metabolic Processes			
ORP (mV)	**Process**	**Electron acceptors**	**Conditions**
+300 +200 +100	1, 2, 3	**O_2**	**Oxic** ***or*** **aerobic**
0 -100	4, 5, 6, 7	**NO_3**	**Anoxic** **anaerobic**
-200 -300 -400	5, 6, 7, 8	**SO_4** **Carbonaceous** **Organics**	**Fermentative** **anaerobic**

1 – Organic
2 – Polyphosphate development
3 - Nitrification
4 - Denitrification
5 – Polyphosphate breakdown
6 – Sulphide formation
7 – Acid formation
8 – Methane formation

A redesigned electrical control system also assisted in the nitrification/denitrification through aerobic/anoxic cycles.

The features of the new electrical control provided for:

- The three phases of the treatment cycle – aerobic, anoxic-settling, and decanting
- Simple adjustment facilities for all cycles.
- Easy to understand for service persons and owners alike.
- Sufficient functions for operating larger commercial systems.
- Control of the phosphorus cycle with chemical precipitation.
- Sludge nutrient removal.

5.2 Putting *Ozzi Kleen* Advanced Secondary Treatment to the Test

In March 2000 an *Ozzi Kleen* RP10 Advanced 10 EP system was set-up for testing at the Maroochydore Sewage Treatment plant. This system was to be tested against the standard of

Advanced Secondary Effluent by the Department of Natural Resources, Queensland. The RP10 does not vary much from the original *Ozzi Kleen* AL4600 system except for the added phosphorus reduction equipment. Within weeks of commissioning the system was giving excellent test results with TKN of <5mg/L, Total N of <10mg/L and Total P of <5mg/L. Test results are shown in Table 6.

TABLE 6. *Ozzi Kleen* Advanced Secondary Effluent Treatment, April 2000

CONSTITUENTS	ADVANCED *OZZI KLEEN* EFFLUENT
Total Kjeldahl nitrogen (TKN)	<5 mg/L
Total nitrogen (TN)	<10 mg/L
Total phosphorus (TP)	<5 mg/L

The first batch of samples was taken in June 2000, with finalisation of the programme in October 2000. Through the entire testing programme, the levels for BOD, NFR, and TC were excellent, with most readings down to <2 mg/L. Test results as shown in Table 7.

TABLE 7. *Ozzi Kleen* Advanced Secondary Effluent Treatment, June 2000

CONSTITUENTS	ADVANCED *OZZI KLEEN* EFFLUENT (mg/L)									
	1	2	3	4	5	6	7	8	9	10
Suspended solids (SS)	5	10	4	3	-	<1	<1	<1	16	-
Total Kjeldahl nitrogen (TKN)	2.0	2.3	4.4	6.2	7.4	8.7	6.7	5.7	6.9	7.7
Total nitrogen (TN)	13.1	13.6	15.6	16.3	16.8	18.7	15.9	14.6	15.5	16.4
Total phosphorus (TP)	2.80	2.62	3.31	3.05	2.78	4.15	4.05	4.56	4.01	4.36
Biochemical oxygen demand (BOD)	<2	<2	<2	<2	-	<2	<2	<2	<2	-

Phosphorus readings were within the limits and, as this is adjustable, it was and is easy to control. The total nitrogen cycle or denitrification presented a challenge. During the winter months the system carried out denitrification, with reasonable results. As summer encroached and the sewage temperatures rose, the denitrification performance dropped off.

Redox readings during the anoxic cycle were 150 mV, which is too high for denitrification. A juggling of the aerobic/anoxic cycles did not give the desired results. The addition of extra carbon was tried for a short period, but found to be difficult to administer, and it would also be difficult to maintain in a domestic situation.

It was discovered there were two main parameters responsible for what was happening:

- suspended solids ratio in the mixed liquor; and
- biomass temperature.

With the increasing temperatures the biomass was being oxidised and reduced in density, as there was insufficient food in the incoming sewage. Because the system was rapidly reducing the BOD to a lower level, there was insufficient carbon residual to drive the denitrification cycle. As the temperature increased, the biological activity increased, stripping out the BOD and oxidising and reducing the biomass. The MLSS in the aeration tank needed to be no lower than 3000 mg/L and the temperature needed to be lower than 25^{o}C.

After commissioning, this system needs to build a biomass that may take some time due to the oxidising process. The addition of extra food may be necessary and would speed things up if the plant were underloaded.

This plant is designed for 2000 L per day with a raw sewage BOD of 250 mg/L and has high oxidation ability sometimes to the point where the biomass is being oxidised as quickly as it is formed. This system has been trialed at 3000 L per day and still gave satisfactory results.

5.3 *Ozzi Kleen* Achieves Advanced Secondary Treatment

An approval in Queensland has been granted for the *Ozzi Kleen* RP10 as an Advanced Secondary Effluent treatment plant.

The advantages of the Advanced Secondary system is that with the higher levels of treatment there should be a relaxation of council requirements such as:

- Relaxed buffer zones to water ways
- Spray irrigation in all areas
- Smaller building block applications
- Reuse of water for specific applications, such as toilet flushing

6. Conclusion

As the scarcity of potable water increases, Australia is not too far behind. *Ozzi Kleen's* aim is to produce the highest quality standard of treated wastewater possible. Experimentation for a better quality effluent, carried out since the first *Ozzi Kleen,* shows that providing end users with a consumer friendly product and a superior quality effluent for re-use is within reach.

The *Ozzi Kleen* system has no influence over water consumption or excess use, but it can recycle the water consumed by renovating wastewater, the end product. *Ozzi Kleen* continues to strive for a purer standard of effluent to maintain public health and a sustainable environment.

Pictures

The author supplied a series of colour photographs that unfortunately could not be reproduced in these Proceedings. Interested parties should contact the author directly. These photographs are listed below:

1. Effluent Reuse Conference, field experiment - Irrigating trees using effluent
2. First Home Grown *Ozzi Kleen*
3. *Ozzi Kleen* manufactured in fibreglass
4. Crack in fibreglass *Ozzi Kleen* due to poor manufacture
5. *Ozzi Kleen* manufactured in marine-grade aluminium
6. *Ozzi Kleen* current polyethylene tank (included as Figure 1 above)
7. & 8. *Ozzi Kleen* commercial treatment plant - White Mining, North Queensland