DUAL PHASE BIOTRICKLING FILTER TREATMENT OF H_2S & VOC'S

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ABSTRACT

The installation of the Beenyup WWTP Biological Odour Control System, supplied by Clean TeQ Limited, supports the acceptance of BioTrickling Filter technology within Australia as the technology of choice for the demanding application of gas phase H_2S mitigation. It also supports a growing trend that has seen advances in design and understanding flow through to the public arena positioning the BioTrickling Filter as the technology of choice not only for H_2S applications, but also for the demanding application of Odour and VOC's mitigation. By utilizing dual stage treatment in a single vessel this project showcases the ability of the Biotrickling Filter as the all-rounder treatment technology for WWTP applications. It has also proven that odour control is no longer considered an afterthought, but is a critical part of the WWTP's process that must be addressed to ensure compliance and operational security.

KEYWORDS

biotrickling filters, bioscrubbers, hydrogen sulphide, wastewater, VOC's, Odour Control.

1.0 INTRODUCTION

The Water Corporation's Beenyup Wastewater Treatment Plant (WWTP) in Perth Australia recently underwent a major upgrade increasing the hydraulic capacity from 120ML/day to a Stage 1 upgraded capacity of 135ML/day. The stage 2 upgrade planned for 2011 will further increase capacity from 135ML/day to a maximum of 150ML/day. Prior to the upgrade, the site utilized chemical scrubbing and activated carbon technologies. For the upgrade Clean TeQ's proprietary OdorTeQ® Dual-Phase biotrickling filter technology was selected and installed offering a quantum leap in the sustainability of the air pollution treatment process. The Clean TeQ system consists of six dual-phase biotrickling filters operating in parallel which remove both hydrogen Sulphide and odour from the air in a single pass. The benefits of this technology include a reduction in capital and operating costs and an increase in efficiency compared to conventional air treatment technologies. The OdorTeQ® Dual-Phase biotrickling filter is a biological process with no chemical inputs which contributes to the minimization of the plants environmental footprint.

2.0 SCOPE OF WORK

As the principal contractor for the Biological Odour Control System (OCS) at the Beenyup WWTP, Clean TeQ Limited was engaged to design, deliver, construct, install, commission and performance prove the Biological Odour Control System. This included the supply of all duct from the inlet of the system to the discharge of the duty/duty/stand-by induced draft fan arrangement, all dampers and isolation valves, instrumentation required to operate the system effectively and the structural infrastructure required to access and maintain the system during its lifetime. The approximate cost to carry out these works was AUD $5.8M.

Figure 1: ***The Biological OCS at the Beenyup WWTP, W.A.***

2.1 The Dual Stage Treatment Philosophy

The OdorTeQ® Dual-Phase odour control concept is the removal of Hydrogen Sulphide in the first stage through the use of the acid producing bacteria Thiobacillus (autotrophs) with remaining odour and Volatile Organic Compounds (VOC's) removed in the second stage in a more pH neutral environment. The concept becomes more challenging when both stages are contained within a single vessel. This was overcome via the use of a continuous recirculation system for the first stage that maintained a low pH environment (1.5-2.0) suitable for the acid producing Thiobacillus. The second stage is designed to be irrigated intermittently with reclaimed effluent, effectively providing the entire system with the desired nutrients whilst flushing the upper bed with a ph neutral solution. This in turn promotes an environment more suited to heterotrophic microorganisms which are thought to be more effective for VOC and odour removal The system was split into two separate trains each made up of 3 OdorTeQ® vessels. A common skid mounted Duty/Stand-by pump system allowed the highest level of flexibility without compromising the system's built in redundancy.

3.0 SYSTEM PARAMETERS

Clean TeQ delivered this project during 2009 with the system coming online early 2010. The installed configuration treats 79,000 Am^3/h of foul gas through a total of 6 towers at an efficiency of 99.5% H_2S removal and 95% odour removal. Key design challenges included integrating the upgrade into a working treatment plant, providing a modular design to minimize onsite work and locating the plant in a limited available footprint.

Through utilization of advanced three dimensional design software, solutions were found to these considerable challenges. Installation of the biotrickling filter system has allowed the decommissioning of one of the chemical scrubbers on site, with the secondary chemical scrubber becoming the polishing system for the treated air. These changes have resulted in a dramatic reduction in chemical consumption on site and a marked decrease in potable water use.

3.1 Stage 1 Upgrade

Table 1 below lists the parameters around which the OCS was designed. Due to the high H_2S levels, sensitivity and close proximity of housing, a conservative approach was adopted to obtain a balance between performance, capital cost and operational cost.

Table 1: ***Stage 1 Beenyup WWTP Upgrade OCS Design Parameters***

Parameter	Units	Average	Peak
Airflow	Am^3/hr (cfm)	79,000 (46,500)	
Hydrogen Sulphide	(ppm_v)	99	214
Methyl Mercaptan	(ppm_v)	1.1	2.1
Ammonia	(ppm_v)	0.5	0.9
Volatile Organic Compounds	(ppm_v)	17	34
Dim ethyl Sulphide	(ppm_v)	12	24

3.2 Normal OCS Operation

Figure 2 below illustrates the simple parallel operational philosophy adopted during design that allowed for future expansion to accommodate the Stage 2 upgrade. Operating the 6 towers in parallel offer flexibility in that each train of 3 towers was grouped via common recirculation piping to reduce cost but maintain flexibility. For each train of 3 vessels a single duty/stand-by pump arrangement was utilized for recirculation of the sump liquor.

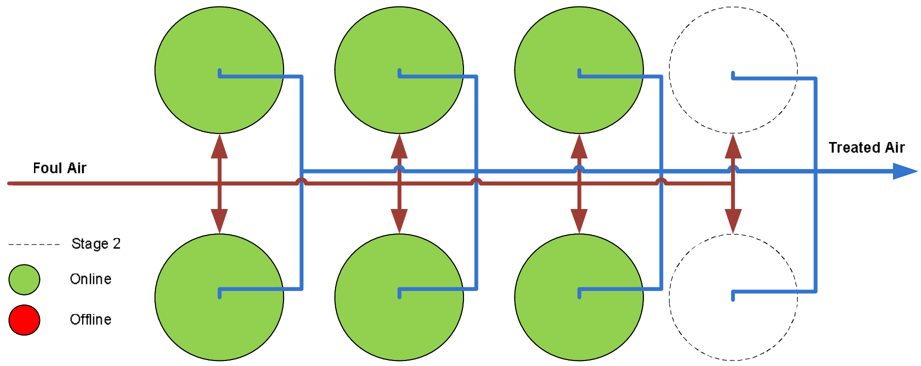


Figure 2: ***Normal Operation of Beenyup WWTP Biological Odour Control System***

During normal operation of the Biological OCS, all six vessels are engaged to ensure maximum residence time and to avoid the possible drying of any of the redundant vessels. Table 2 details the general operational parameters that the system is designed around. Importantly 17 seconds is the total EBRT for the system and includes both the acidic H_2S treatment stage as well as the Odour/VOC stage.

Table 2: ***Stage 1 Beenyup WWTP Upgrade OCS normal operational requirements***

Parameter	Units	Measurement
Total Flow	Am^3/hr (cfm)	79,000 (46,500)
Air Flow per Vessel	Am^3/hr (cfm)	13,167 (7,750)
Empty Bed Residence Time (Total)	Sec	17.0
Superficial Bed Velocity	m/s (fps)	0.45 (1.48)
Performance Requirements		
H_2S Reduction	% or ppm	≥ 99.5 or ≤ 0.25
Odour Units Reduction	% or OU	≥ 95 or $\leq 5{,}000$

3.3 Operation during OCS Maintenance

Figure 3 illustrates the operability of the system if a single tower is to be isolated for maintenance purposes. The system is designed for full operational capacity and performance whilst being operated in this configuration.

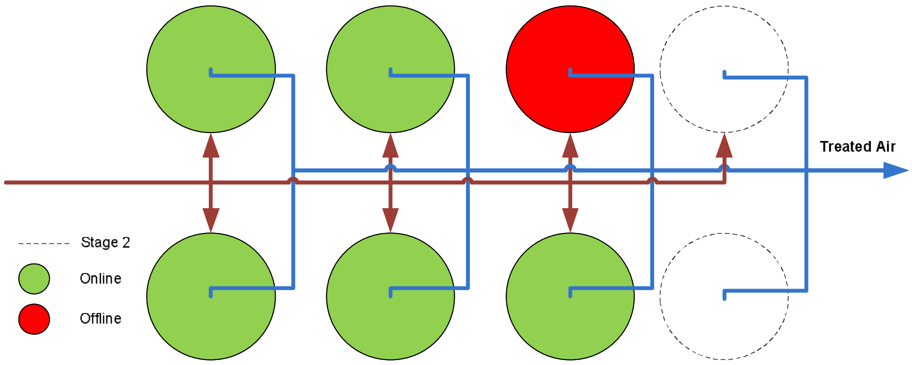


Figure 3: ***Maintenance Operation of Beenyup WWTP Biological Odour Control System***

Table 3 illustrates the reduced EBRT and increased velocity that is experienced through the system whilst still maintaining optimum performance.

Table 3: ***Stage 1 Beenyup WWTP Upgrade OCS Maintenance Operational requirements***

Parameter	Units	Measurement
Total Flow	Am^3/hr (cfm)	79,000 (46,500)
Air Flow per Vessel	Am^3/hr (cfm)	15,800 (9,300)
Empty Bed Residence Time (Total)	Sec	14.15
Superficial Bed Velocity	m/s (fps)	0.54 (1.77)
Performance Requirements		
H_2S Reduction	% or ppm	$\geq$ 99.5 or $\leq$ 0.25
Odour Units Reduction	% or OU	$\geq$ 95 or $\leq$ 5,000

The Stage 2 upgrade involves an increase in airflow from the 79,000Am^3/hr (46,500cfm) to a total capacity of 101,700Am^3/hr (59,860cfm).

Table 4: ***Stage 2 Upgrade OCS Design Parameters***

Parameter	Units	Average	Peak
Airflow	Am^3/hr (cfm)	101,700 (59,860 cfm)	
Hydrogen Sulphide	(ppm_v)	93	207
Methyl Mercaptan	(ppm_v)	1.2	2.4
Ammonia	(ppm_v)	0.6	1.2
Volatile Organic Compounds	(ppm_v)	17	33
Dim ethyl Sulphide	(ppm_v)	12	23

3.4 Design Challenges

Undertaking this project presented the engineers with numerous design challenges that ranged from operator access and maintenance, to the successful integration of a dual stage biological system in a single vessel.

The sheer size of the plant also raised issues with duct of 2,000mm (6’7”) in diameter and each reactor vessel sized at 3,200mm (10' 6") in diameter and 13,000mm (42' 8") in height. Future proofing was also a major consideration as the system had to be designed with flexibility for expansion given the high likelihood of increased capacity requirement in the not too distant future. 3D design package, Solidworks™, was utilized in the design process to eliminate installation clashes and optimize the operability of the system. Also used during HAZOP and HAZID workshops, the 3D landscape proved invaluable in ensuring the clients expectations were incorporated into the design prior to fabrication beginning.

3.5 Flexibility vs. Functionality

A key design feature of the system is the ability to increase the treatment capacity via the addition of two (2) further towers, taking the total number of bioscrubber reactor vessels from the currently installed 6 to a total of 8. The inclusion of the final two towers will take the system capacity from the installed 79,000m^3/hr (46,500CFM) to the ultimate capacity of 101,700m^3/hr (59,860CFM). This flexibility had to be designed into the functionality of the system as part of the initial design to ensure that the future upgrade could proceed as seamlessly as possible. The issue of flexibility is overcome via the inclusion of the central air disribution manifold and central access platform. Clean TeQ was able to modularize the platform to enable the retrofit of a bolt on section to ensure ease of access to towers 7 and 8 once installed.

The induced draft fans, operating on variable speed drives, offered sufficient capacity in both flow and pressure to avoid the potentially expensive change over to service the furture increased capacity of the plant.

3.6 The Installed OCS

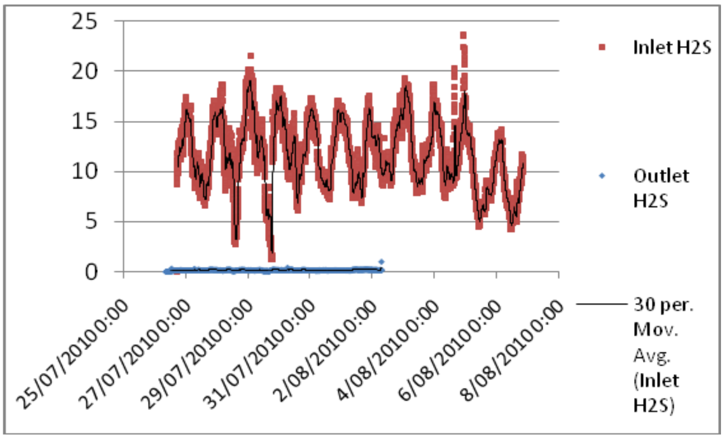
The installed OCS at the Beenyup WWTP stands at 15m (50ft) tall and has a footprint of approximately 30m (100ft) x 25m (82ft). During the next staged upgrade, the additional 2 vessels will have no impact on the footprint with the major change being an extension to the access structure.

Due to the extensive upfront design, all other parameters including pump volumes, fan volumes and pressure, drain load and instrumentation associated with the successful operation of the upgraded system have been incorporated into the Stage 1 design.

Figure 5: ***The Biological OCS as installed at the Beenyup WWTP, W.A.***

4.0 SYSTEM PERFORMANCE

The system is more than capable of treating a full range of H_2S effectively as illustrated below. This graph shows clearly the OdorTeQ® BioTrickling Filter handling the fluctuating loads typical of the treatment plant emissions.



<u>Figure 6:</u> ***H2S Removal Performance at the Beenyup WWTP, W.A.***

Odour and VOC's on the other hand are rather subjective, as evidenced by the +/-20% accuracy on their measurement through the commonly employed dynamic olfactometry method. The table below represents a set of samples taken across four days measuring odour concentration at both the inlet and the outlet of the OdorTeQ® BioTrickling Filter system.

<u>Table 5:</u> ***Dynamic Olfactometry Performance at the Beenyup WWTP, W.A.***

Parameter	Units	Inlet	Outlet
Day 1, am	(OU)	15,000	2,600
Day 1, pm	(OU)	12,000	4,300
Day 2, am	(OU)	21,000	5,200
Day 2, pm	(OU)	16,000	5,300
Day 3, am	(OU)	10,000	4,300
Day 3, pm	(OU)	17,000	3,200
Day 4, am	(OU)	11,000	3,700
Day 4, pm	(OU)	15,000	3,200

5.0 CONCLUSIONS

Large scale BioTricking Filter systems for the treatment of gas phase odour at Australia's WWTP's have reached the point of best practice in Australia. This system at Beenyup's WWTP not only proves the effectiveness of the technology, it also puts BioTrickling Filter Technology on a platform that illustrates what can be achieved if foresight and design tools are used effectively during the design stages. Odour control can no longer be looked upon as the afterthought, but as an integral part of the planning, construction or upgrade of any major wastewater facility. Through continued research and development and ongoing competition in the marketplace advances to these sustainable solutions to odour mitigation will continue. Innovations incorporated in projects such as Beenyup's WWTP Upgrade demonstrate that these improvements will lead to more cost effective, smaller, lower impact and more sustainable Biological solutions for the future.