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# Odour Control for the Bondi Road Sewage Pump Station

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*Abstract:* The Bondi Road Sewage Pump Station is a Melbourne Water asset located at Bon Beach, Victoria. The pump station sits amidst residential properties whom are sensitive to odour due to a history of odour nuisance. As part of a recent upgrade, a new Air Treatment Facility (ATF) was installed to eliminate odour emissions to the surrounding community. This comprised a biotrickling filter (BTF) followed by activated carbon filtration. The BTF removes hydrogen sulphide and other volatile odorous compounds in a cost effective and environmentally sustainable manner. It operates by the absorption of pollutants into an aqueous phase which is irrigated intermittently over an inert packing material with a high surface area and contains a unique blend of bacteria. With the addition of oxygen and nutrients, the bacteria oxidise the compounds through a range of enzyme catalysed reactions to obtain energy and enable cell maintenance and reproduction. The result is the formation of non-odorous reaction products such as carbon dioxide, water and salts. The activated carbon filters provide polishing of the outlet stream in order to achieve the stringent discharge requirements. A rigorous performance test was undertaken and demonstrated removal efficiencies for hydrogen sulphide and odour through the BTF alone of >99.7% and 98.9% respectively with odour removal through the complete facility of 99.9%. The removal efficiency through the BTF is considered to be exceptional considering the relatively low gas residence time of the BTF and will result in substantial savings in activated carbon replacement throughout the life of the facility.

*Keywords:* air treatment, biotrickling filter, activated carbon, odour, hydrogen sulphide.

## 1 Introduction

The Bondi Road Pump Station was constructed by the Chelsea Sewage Authority in the mid-sixties, and has operated mostly unchanged since that time. The installed equipment and structures, which included an activated carbon filter based odour treatment system, have functioned well during this time but are now in need of repair. Over the last several years, noise and odour emissions have also affected the local amenity of surrounding residents. In order to address these issues, various options to upgrade the pump station were evaluated by Melbourne Water with the following activities adopted:

- Renew the pumping equipment
- Renew and upgrade the Air Treatment Facility (ATF)
- Extend and refurbish the building
- Update the station control system
- Refurbish the station infrastructure

The upgrade was delivered through the Pipeline Alliance. Aromatrix Australia (now CleanTeQ Aromatrix) were awarded the contract to deliver the ATF.

Air dispersion modelling was undertaken to determine the allowable outlet odour concentration from the new ATF. This confirmed that a concentration of 400 OU would be required to ensure that ground level odour concentrations did not exceed the Victorian EPA's requirement of 1 OU beyond the plant boundary.

## 2 Air treatment facility

The treatment technology selected for the ATF consisted of a first stage biotrickling filter (AroBIOS™ BTF system) followed by a duty/standby second stage AroCARB™ activated carbon polishing system prior to atmospheric discharge (refer Figure 1).

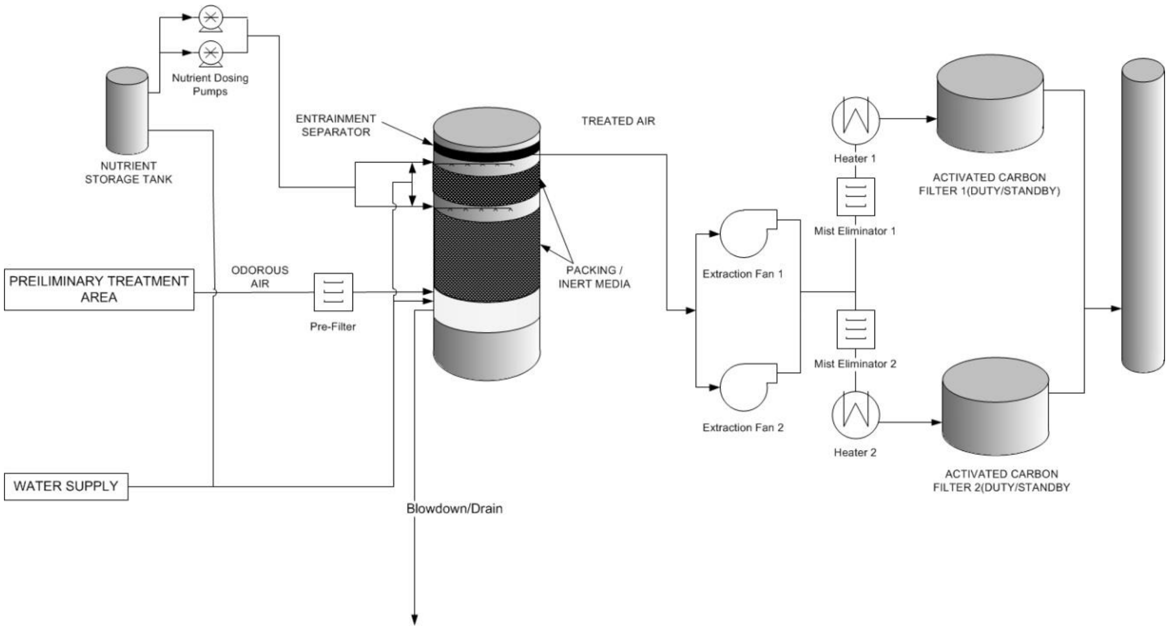


**Figure 1**: ATF process schematic

**Figure 2**: Biotrickling Filter (nutrient tank in the foreground)

**Figure 3**: Activated Carbon Filter (one of two units installed)

BTFs are a cost effective and environmentally sustainable treatment method compared to most other forms of treatment (e.g. wet chemical scrubbing, thermal oxidation) and operate by the absorption of pollutants (such as hydrogen sulphide, mercaptans, dimethyl sulphide and other volatile odorous compounds) into an aqueous phase which is irrigated either continuously or in the case of the Bondi Road facility, intermittently over a packing material with a high surface area and contains a unique blend of bacteria (Figure 4).

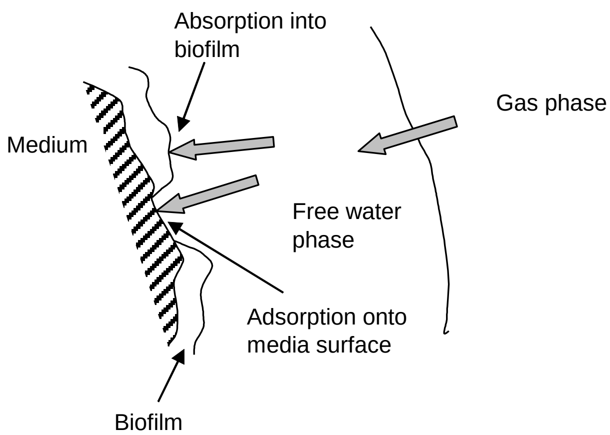


**Figure 4**: Mass transfer concept

With the addition of oxygen and nutrients, the bacteria oxidise the compounds through a range of enzyme catalysed reactions to obtain energy and enable cell maintenance and reproduction. The result is the formation of non-odorous reaction products such as carbon dioxide, water and salts.

*Organic compounds + Oxygen ----> $CO_2$ + $H_2O$ + Salts + Energy + Biomass*

In the degradation of hydrogen sulphide, carbon dioxide is utilised to form acid and salts.

*Hydrogen sulphide + $CO_2$ ----> $H^+$ + Salts + Energy + Biomass*

Hydrogen sulphide and other sulphur based compounds are amongst the most odorous due to their low odour threshold concentrations and are typically found in municipal wastewater treatment as well as a number of other odour generating industries. *Thiobacillus sp*. effectively degrades these compounds under low pH conditions and are a dominant bacterial species within BTFs treating sewage type waste streams.

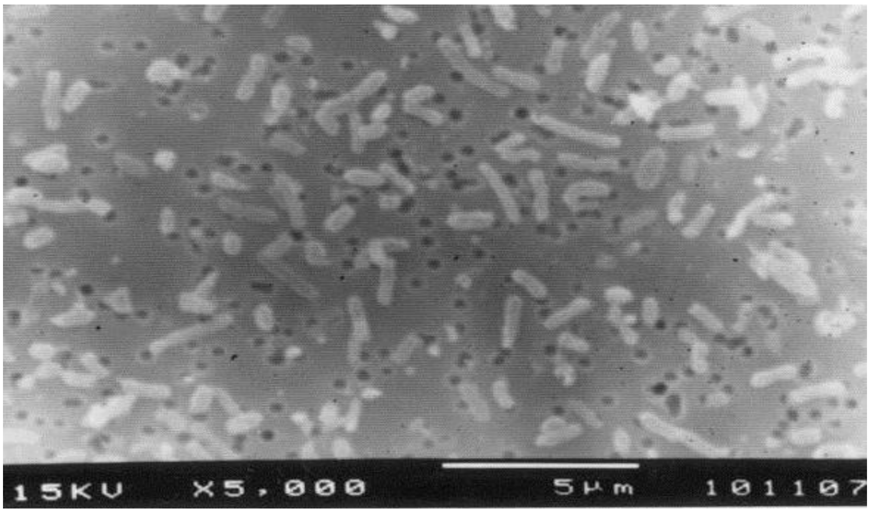


**Figure 5**: Scanning electron micrograph of Thiobacillus spp. (within BTF recirculating fluid)

The control of pH within BTFs is easily achieved and so reaction processes that result in the formation of acids, or ammonia and nitrates (through the oxidation of nitrogen based organic compounds) do not create the same problems as other biological treatment methods (e.g. compost or soil bed biofilters). Upstream humidification of the air stream is not required due to the irrigation and packing wetting methods.

Unlike wet chemical scrubbers, BTFs do not require the use of hazardous chemicals for treatment, nor do they have the same challenges associated with their disposal. The only 'chemical' required to be dosed into a BTF is a non-hazardous nutrient solution required for bacterial growth where potable water is used as the feed water. Only minor dosing rates are required (i.e. approximately 1 L/d) in order to provide the trace compounds necessary for effective bacterial growth.

Where reclaimed water is available as the water feed source, after say secondary or tertiary wastewater treatment stages, this generally has sufficient nutrients and so additional nutrient dosing is not required and can therefore be eliminated. For the Bondi Road site, potable water is used as the feed source and therefore nutrient dosing is required.

The pH of the waste stream ('blowdown') produced by the BTF is between 2-3 and is controlled through the irrigation rate over the packing. This liquid waste stream is directed to the sewer and since the flowrate is very small compared to the sewerage flowrate, it does not have an adverse impact on the pH of the sewage.

After treatment through the BTFs, the air is directed through duty / standby in-line air heaters which raise the gas temperature by $5^{0}C$ resulting in an approximate 15-25% reduction in the relative humidity. This reduction in humidity reduces the potential for condensation to occur as the air passes through the activated carbon filters. This is desirable as any moisture present within the gas stream will take up pore spaces within the carbon media reducing its capacity to adsorb the remaining contaminants, and thereby reducing the carbon bed life.

Single deep bed activated carbon filters were installed as the second stage polishing system in order to achieve the stringent outlet odour concentration of 400 OU. Activated carbon removes odorous pollutants via the process of adsorption, chemisorption or both. Two carbon types were used within the Bondi Road facility: carbon impregnated with sodium hydroxide, which is used to adsorb hydrogen sulphide and other small molecular weight compounds, and un-impregnated carbon used to adsorb most of the remaining compounds, in particular the removal of long chain molecular weight compounds.

## 3 Performance testing

Inlet design loads and performance requirements are listed in Tables 1 and 2 respectively. Continuous monitoring of hydrogen sulphide ($H_2S$) on the inlet and outlet of the ATF was carried out during a 14 day test period using fixed instrumentation. Discrete sampling was also carried out on the BTF inlet, BTF outlet and stack discharge on six of the 14 days. Samples were collected at 6:00am, 1:00pm and 9:00pm in order to establish concentration variations over a 24 hour period. These samples were tested for $H_2S$ and odour as per the methods listed in Table 3.

The performance test was carried out between 20th March 2014 and 2nd April 2014 with an overall summary and statistical analysis of the results presented in Table 4.

**Table 1:** ATF Inlet design loads

| Description | Units | Min | Avg | Max | Winter Avg | Summer Avg |
|---|---|---|---|---|---|---|
| Hydrogen sulphide ($H_2S$) | ppm | 0 | 3 | 24 | n/a | n/a |
| Odour concentration | OU | n/a | n/a | n/a | 7,000 | 15,000 |
| Volatile Organic Compounds (VOC) | ppm | n/a | 0.6 | 2 | n/a | n/a |

Notes: Based on ambient temperature of 0-40 degrees Celsius.

**Table 2:** Performance Requirements

| Description | Min | Max | Average | Maximum outlet concentration |
|---|---|---|---|---|
| *Hydrogen sulphide* | | | | |
| Biotrickling Filter | 98% | 99.5% | 99% | 0.05 ppm |
| Activated Carbon Filter | 99% | 99.5% | 99% | 0.01 ppm |
| *Odour* | | | | |
| ATF Discharge | | | | <400 OU |

Notes: The maximum $H_2S$ outlet concentration refers to when the guaranteed minimum $H_2S$ removal efficiencies cannot be achieved due to low inlet concentrations.

**Table 3:** Gas testing methods

| Parameter | Testing Method | Notes |
|---|---|---|
| Hydrogen Sulphide | BTF inlet & outlet: Installed Canary 'SmarTox-O' utilising the electrochemical cell sensing method<br>Stack discharge: Installed Honeywell Chem-cassette SPM utilising the paper tape optical sensor method | Online (fixed in place) analysers |
| Hydrogen Sulphide | Jerome 631 Gold Film Hydrogen Sulfide Analyser | For verification of online (fixed in place) analysers |
| Odour | Olfactometry to AS4323.3:2001 "Air Quality – Determination of odour concentration by Dynamic Olfactometry", at an approved laboratory. | |

**Table 4:** Performance Trials Results

| Parameter | Min (ppm)[1] | Ave (ppm)[1] | Max (ppm)[1] | No. of Samples | Std.Dev. | Average Removal Efficiency Measured | Discharge Efficiency/ Concentration Required |
|---|---|---|---|---|---|---|---|
| *Inlet to Biotrickling Filter* | | | | | | | |
| $H_2S$ – On-site Canary analyser | 0 | 1.48 | 5.13 | 9,901[2] | 0.93 | | |
| $H_2S$ – Jerome analyser | 0.85 | 3.66 | 6.2 | 14 | 1.63 | | |
| Odour (OU) | 5,900 | 52,420 | 89,000 | 14 | 26,270 | | |
| *Outlet of Biotrickling Filter* | | | | | | | |
| $H_2S$ – On-site Canary analyser | 0.00 | 0.03 | 0.96 | 9901[2] | 0.02 | 98.0%[3] | 99% <0.05 |
| <0.05$H_2S$ –Jerome analyser | <0.01 | <0.01 | <0.01 | 14 | 0.00 | >99.7%[4] | 99% <0.05 |
| Odour (OU) | 340 | 580 | 1,000 | 14 | 228 | 98.9% | |
| *Stack outlet* | | | | | | | |
| $H_2S$ – On-site Honeywell analyser | 0.000 | <0.01 | <0.01 | 9,901[2] | 0.00 | >99.3%[4] | 0.01 |
| $H_2S$ – Jerome analyser | <0.01 | <0.01 | <0.01 | 14 | 0.00 | >99.7%[4] | 0.01 |
| Odour (OU) | <30 | 53 | 120 | 14 | 28 | 99.9% | <400 |

Notes
1 Concentrations in ppm unless specified
2 Continuous monitoring
3 Removal efficiency based on Canary H2S analyser on BTF inlet
4 Removal efficiency based on Jerome H2S analyser on BTF inlet

## 3.1 Hydrogen Sulphide

**BTF Inlet**

With respect to hydrogen sulphide, the monitoring trend from the BTF inlet Canary 'SmarTox-O' shows low concentrations over the 14 days with an average concentration of 1.48 ppm and a peak of 5.13 ppm. Discrete sampling via the Jerome analyser showed an average concentration of 3.66 ppm. The peak concentration recorded by the Jerome analyser was 6.2 ppm.

**BTF Outlet**

On the BTF outlet, the Canary 'SmarTox-O' unit showed very low concentrations throughout the 14 day performance trial. The average concentration over the trial period was 0.03 ppm, with a peak concentration of 0.96 ppm. The average outlet $H_2S$ concentration from the BTF (0.03 ppm) is below the specified design removal concentration of 0.05 ppm. Discrete sampling via the Jerome analyser recorded all concentrations <0.01 ppm. Again, these concentrations are well below the specified design removal concentration of 0.05 ppm. It is worth noting that the Canary analyser on the outlet was found to read 'high'. These high readings were confirmed through comparison with the Jerome analyser results and independent gas testing performed by Melbourne Water.

Based on the results from the Jerome analyser, the average removal efficiency was >99.7%, which exceeds the 99% requirement. The maximum removal efficiency was >99.8%, while the minimum removal efficiency could not be properly established due to the low inlet concentrations, some of which were zero.

**Activated Carbon Filters**

The removal efficiency of $H_2S$ across the activated carbon filters could not be established since most concentrations were below the detection limit of the analysis techniques.

**ATF Discharge**

Monitoring of hydrogen sulphide on the stack via the Honeywell Chem-cassette SPM analyser showed very low concentrations with all readings <0.01 ppm. Discrete sampling via the Jerome analyser also recorded all concentrations <0.01 ppm.

## 3.2 Odour

**BTF**

The inlet odour concentrations to the ATF were quite variable ranging from a low of 5,900 OU up to 89,000 OU with an average of 52,420 OU. The BTF outlet concentrations ranged from 340 OU to 1,000 OU with an average of 580 OU and a corresponding removal efficiency of 98.9%. This is extremely high for BTF systems, especially considering the relatively low gas residence time of the BTF (i.e. 14s).

**ATF**

The average and maximum odour concentrations measured at the outlet of the activated carbon filters and prior to stack discharge was 53 OU and 120 OU respectively. These are significantly less than the discharge limit of 400 OU. The corresponding average odour removal efficiency across the ATF was 99.9%.

# 4 Conclusions

The high $H_2S$ and odour removal efficiencies measured across the BTF demonstrate the ability of biological systems to provide exceptional treatment performance for a range of odorous compounds. Where very low outlet odour concentrations are required and therefore the need for secondary treatment is necessary, this also has the added benefit of limiting the size and complexity of these subsequent treatment stages. In the case of activated carbon, the high removal efficiencies of the BTF substantially reduce the operating costs associated with carbon replacement and power costs leading to whole of life cost savings.

Based on the results of performance testing and an absence of complaints since it was commissioned over 12 months ago, the key deliverable of the ATF to mitigate odour nuisance to the community has been achieved. The facility is therefore a valuable asset to Melbourne Water and the Community.

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