- Case Study: Odor removal at a municipal wastewater treatment plant

I. Introduction of the Site and the System

The neighborhood around this wastewater treatment plant is extremely sensitive to bad odors. The South Walton Utility Company (SWUCI) wastewater reclamation plant is located in the middle of residential housing area, close to a hotel and the beach (< 0,5 mile). A lot of tourists visit South Walton especially during summertime when the generation of odors from the wastewater treatment plant is the highest.

II. Design Comments

The engineering firm CDM conducted a study and found that most of the plant odor came from the primary screen and grit removal system. They enclosed these odor sources and selected a Bioway bioifiltration system to treat the exhaust from the enclosed processes.

The following design criteria were specified: An airflow of 2600 m^3 /h (1000 cfm) containing many odorous compounds including average hydrogen sulphide concentrations of 60 ppmv (max 120 ppmv) and a odor concentration of about 4000 D/T.

The following acceptance criteria were specified:
Criterion 1: 99% removal of hydrogen sulfide (or lower than 0,5 ppmv)
Criterion 2: 90% removal of total organic reduced sulfur compounds
Criterion 3: 90% odor removal

Also important criteria are of course the operational costs, the quality of the bioreactor for acid conditions, maintenance requirements and no odor impact off site.

III. Operation of the System

Start-up:
During the start-up a start-up kit is used. This 300 liter vessel contains an acid resistant pump and a water level control. The vessel was first filled with water, nutrients and biology (the biology used is a combination of prepared inoculum and activated sludge) The pump recirculates discontinuously the water over the media in the bioreactor in order to have the micro-organisms grow on the inert media inside the bioreactor. The water level of the 300 liter vessel automatically fills back up when the water level reduces due to water evaporation from the bioreactor. The relative humidity of the outgoing air from the bioreactor is saturated with water (relative humidity is 100%), while the incoming air is normally not saturated (relative humidity is approximately 50-80%). The airflow was during the first week set at about 50% of the design airflow to prevent too much untreated odors leaving the bioreactor during this start-up phase. After the first week the airflow was set at 100% of the design airflow (1700 m3/h). After a period of 3 weeks the start-up kit (with the recirculation pump) was disconnected and removed and the system control was changed over from start-up operation to normal operation.

Normal operation:
During normal operation water (effluent water from the wastewater treatment plant) was discontinuously added to the bioreactor. Every 10-15 minutes a small amount of water was added to the bioreactor. During the first two months nutrients were added to the ingoing water, because the used effluent water from the wastewater treatment plant was relatively very clean at this wastewater treatment plant. After

the first two months the nutrient feed was stopped was only effluent water from the wastewater treatment plant was used. The pH of the drain-water from the bioreactor was kept at pH=2.
During normal operation no special attention has to be paid to the bioreactor other than checking the blower operation and the strainers in the water panel taking out small amounts of residual suspended solids from the effluent water. Once a week the bioreactor was checked by the plant operator by measuring the inlet and outlet H2S-concentrations (removal), the pH of the drain-off water and checking the smell of the air coming from the bioreactor.

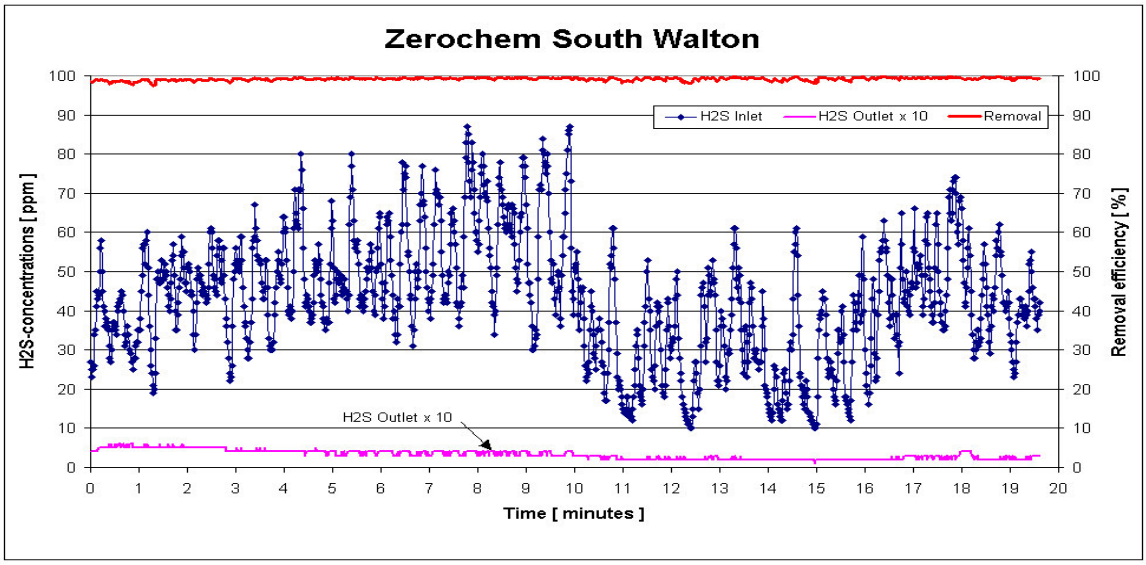
IV. Performance

Start-up
The start-up was monitored by measuring the pH of the drain-off water from the bioreactor and the hydrogen sulphide in the inlet and outlet waste gas of the bioreactor. The pH in the bioreactor started to drop already after 1 day also showing that the removal of reduced sulphur compounds was started. After a week the removal of H2S was > 90 % and after the 16 days the removal of H2S was > 99% (data not shown). The plant operator performed the measurements during the start-up period according start-up instructions of Bioway.

Normal operation:
During normal operation the plant operator checked daily the bioreactor by checking the fan running and alarm signals present. Every week the pH of the effluent water and the hydrogen sulphide removal efficiency is measured.

After the start-up period the bioreactor performance was measured by analyzing:
- Online inlet and outlet H2S-concentrations (using Odalogs; type with the range 0-200ppmv for the inlet air and the type with the range 0-50 ppmv for the outlet air)
- Odor concentrations of the inlet and outlet air (during approximately half hour air samples were collected in a Tedlar bag and sent to a lab (St-Croix Sensory Inc.) for determination of the odor-concentration using the ASTM 679-99 standardized method at an airflow of 20 liter/min.
- Reduced sulphur compounds other than hydrogen sulphide were measured by Air Toxics Ltd, using standardized method ASTM D 5504. This method uses GC-MS and measures the concentrations of 19 different organic reduced sulfur compounds.

The inlet odor concentration was higher than specified (5500 D/T) and the flow rate was also higher than specified (1200 cfm) The system met the first two criteria but there was a odor in the outlet with a concentration of 690 D/T. The flow rate was reduced to 1000 cfm to increase detention time as specified. The biofilter was the re-tested. The outlet odor concentration decreased to 310 D/T and the odor character improved. SWUCI was then completely satisfied with the performance of the Bioway system.



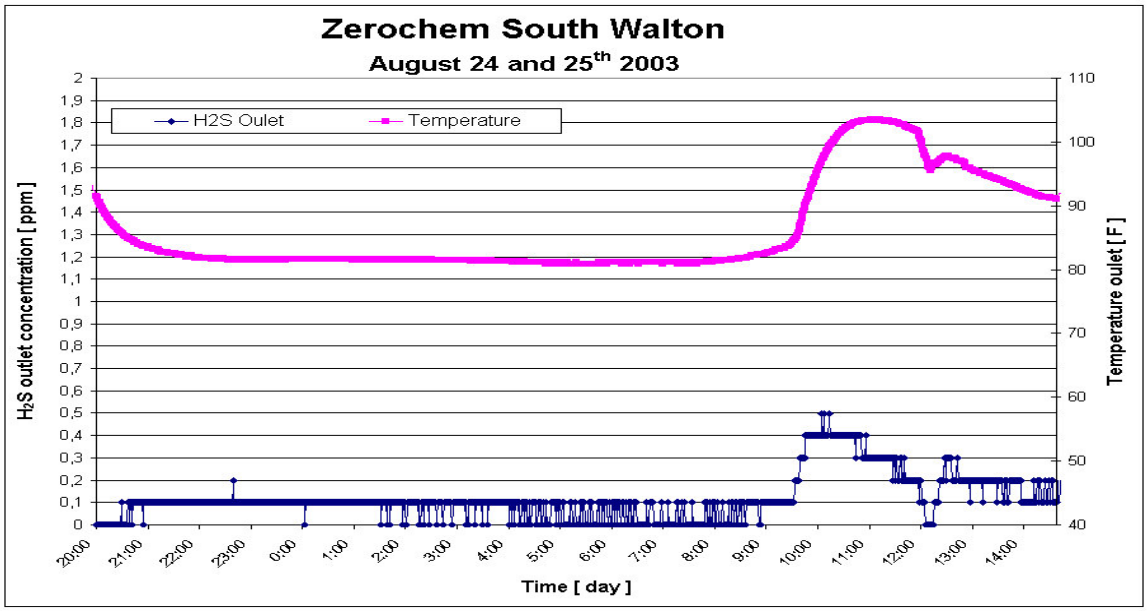
Graphic 2: Hydrogen sulphide removal after 8 weeks from the start-up *.

Table 1: Removal efficiencies of the bioreactor of hydrogen sulphide, reduced sulphur compounds and odors after 8 weeks from the start-up*.

Pollutant	**Unit**	**Inlet Concentration**	**Outlet Concentration**	**Percent Removal**
Hydrogen sulfide (48 hours before taking bag samples: see Graphic 2)	ppbv	10000-87000	100-500	99%
Hydrogen sulfide (in bag samples)	ppbv	17000	320	98 %
Organic reduced sulfur compounds:				
Methyl mercaptan	ppbv	430	16	
Carbonyl sulfide	ppbv	0	16	
Isopropyl mercaptan	ppbv	0	13	
Total reduced sulfur	ppbv	430	45	90 %
Odor concentration	D/T	5500	690	87 %

* at 20% more airflow (2040 m3/h in stead of 1700 m3/h)

After a period of normal operation odor measurements were repeated to see whether the performance was still according the design criteria. After a period of approximately four months of normal operation the bioreactor odor and H2S removal performances was measured.



Graphic 3: Outgoing hydrogen sulphide concentrations during 18 hour period after four months of operation.

Table 2: Removal efficiencies of odors after four months of operation.

Pollutant	**Unit**	**Inlet Concentration**	**Outlet Concentration**	**Percent Removal**
Odor concentration	D/T	7800	310	96 %

Dispersion modeling:

An EPA SCREEN model was ran by CDM to determine the odor impact at the nearest receptor points. The nearest receptor points at a distance of 25 and 100 meter. Three different outlet duct configurations of the bioreactor were calculated: with and without rain hat and with and without a 4 feet stack extension. Table 3 shows the results of the highest odor impact at ground level under worst-case meteorological conditions. The nuisance threshold is typically in the range of 2 to 5 D/T. It can be concluded that all configurations result in little or no odor impact off site. The 4 feet stack extension without rain hat reduced the off site odor impact significantly.

Table 3: Results modeling the odor impact at the nearest receptor points with different outlet duct configurations of the bioreactor.

Condition	**Distance from outlet bioreactor (meter)**	**Highest ground-level odor concentration (D/T)**
Existing bioreactor height, with rain hat	25 100	2,8 1,1
4 feet stack extension, with rain hat	25 100	2,5 1,2
4 feet stack extension, exit cone and no rain hat	25 40 100	0,2 0,4 (distance of maximum impact) 0,3

Operation at increased airflow:
On February 17th 2004 the H2S- and odor-removal was measured at a 50% increased airflow. 3 week prior the measurements the airflow was increased from 1000 cfm to 1525 cfm. The H_2S-concentrations in the inlet waste gas was very low (< 10 ppmv) due to the relative cold weather conditions (air temperature on the outlet of the system was app. 54 °F). The Zerochem-installation showed, unless the 50% increased airflow, the low inlet H_2S-concentrations and the low air temperatures, a H_2S-removal of more than 99% (see Table 4). This high H_2S-removal resulted in very low outlet H_2S-concentrations (< 0,1 ppmv). The odor-removal was determined at the 50% increased airflow and showed to be still very high (> 90%). The outlet odor-concentration was 540 D/T.

Table 4: Removal efficiencies of hydrogen sulphide and odors at a 50% increased airflow.

Pollutant	**Unit**	**Inlet Concentration**	**Outlet Concentration**	**Percent Removal**
Hydrogen sulfide	ppbv	9400	13	99,9%
Odor concentration	D/T	5700	540	90,5 %

V. Table

Table 5: Case study of odour removal at a municipal wastewater treatment plant.

Reactor Type	Zerochem™
Owner and location	Municipality of South Walton
Manufacturer	BIOWAY bv (Ede, The Netherlands)
Year of installation	2002
Type of air stream	waste gas from the inlet channel, grit chamber, screening room, grit classifier and auxiliary pump station.
Reactor dimensions and construction type	Zerochem™ type ZC3000 with control panel; housingmaterial FRP with PVC lining inside for the protection against sulphuric acid.
Medium type	Permapac™ (structured, open, inert media, which is resistant to low pH conditions)
Number of layers of medium	2 layers
Air flow rate	Operated at 1700 m3/h and designed up to 2000 m3/h
Pressure drop	< 75 Pa (< 0,3 inch WK)
Average bed temperature	20 °C
Contaminants treated	Odorous compounds among them hydrogen sulphide and reduced sulphur compounds
System controls	Automatic water and nutrient feed by PLC. Alarm generation for different unwanted situations like for example low or no waterflow or low nutrient level.
Design and acceptance criterion	Criterion 1: 99% removal of hydrogen sulfide (or lower than 0,5 ppm) Criterion 2: 90% removal of total organic reduced sulfur compounds Criterion 3: 90% odor removal
Typical performance	➢ > 99% hydrogen sulfide-removal ➢ > 90% reduced sulfur compound (other than H2S) removal ➢ **> 95% overall odor-removal**

Figure: Biotrickling reactor treating odorous air from at a municipal wastewater treatment plant.