Pump station wet wells are often sources of odor release because odor bearing air is pushed out of the wet well as it fills with wastewater. In addition, this air tends to move downstream with the wastewater flow and is discharged at the wet well. Potential solutions for this problem include liquid-phase treatment, wet well aeration, and vapor-phase control of emissions (WEF 2004).

Where the release of odors cannot be avoided, effective odor treatment is required. The odor treatment plant must first be able to collect odorous air and avoid fugitive release of odors. Keeping negative pressure on the system is essential. Secondly, the treatment method must be capable of sufficient treatment of odor under constantly changing conditions.

An effective odor control system must provide the following key conditions:

- Odor must be treated as a complex mixture of substances – effective treatment of single chemical compounds is not sufficient
- The system must be capable of treating highly concentrated odors
- The system must be fast acting and capable of treating varying odor concentrations (e.g., from below 100 ppm up to 600 ppm H2S at pump stations)
- The system must work with high air humidity and must be able to handle other pollutants, like micro-organisms included in the air

### Odor Treatment

Treatment of odors offers choices in the processes available. According to the Chartered Institution of Water and Environmental Management (CIWEM 1998), factors which influence the choice of process include:

- The maximum allowable odor intensity at the boundary of the site
- The flow rate of air to be treated
- The type and concentration of odorous compounds including variability in concentration
- The space available for the odor treatment process

Among the most commonly known odor treatment methods are:

- **Biofilters and bioscrubbers** – the use of micro-organisms to oxidize odor compounds
- **Wet chemical scrubbing** – the use of different chemical additives to compound odor species from the gas stream, leaving a chemical waste for disposal
- **Dry scrubbing** – adsorption of odor compounds with an adsorption media (such as activated carbon)

These treatment methods are well known and described in professional literature (e.g., CIWEM 1998, WEF 2004). A relatively new treatment method for wastewater odors, which is not yet widely

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found in literature, is the photo ionization process. This process provides some essential benefits, especially when it comes to high efficiency requirements and high odor concentrations.

**Photo Ionization**

Photo ionization has been in use for more than 10 years and is the treatment of substances under radiation of ultraviolet (UV) light in the presence of a catalyst. The Claus reaction (named after Carl Friedrich Claus) demonstrates the oxidation of H₂S (desulfurization) as follows:

\[
\text{H}_2\text{S} + 2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{SO}_2
\]

\[16\text{H}_2\text{S}(g) + 8\text{SO}_2(g) \rightarrow 3\text{S}_8(g) + 16\ \text{H}_2\text{O}\]

This effect may be observed at volcanoes, where H₂S gas is released and oxidized under the influence of sunlight (natural UV light) to elemental sulfur in the presence of a catalyst.

Photo ionization has been found to provide a large number of benefits, especially in the treatment of the most challenging odors, such as from pump stations and collection systems. The system is able to handle high humidity gas streams, up to 100 percent RH (relative humidity). The nature of the process ensures RH reduction with temperature increases of 5-10°C from the inlet to the outlet.

Field professionals have reported (Bartkowska 2007) odor reduction rates of more than 99 percent by photo ionization when treating off-gas from a sludge digestion or ATAD plant (autothermal thermophilic aerobic digestion), with results described as: raw off-gas > 60,000 OU/m³ (odor units per cubic meter), cleaned gas 130-640 OU/m³.

When the contaminated air enters the ionization chamber, UV light is adsorbed by oxygen and by the contaminant molecules. Thus, UV light produces oxygen radicals and hydroxyl radicals while, simultaneously, contaminant molecules may be broken up. Substances are degraded under UV radiation on the surface of the catalyst. The system addresses all incoming odorous substances. Micro-organisms are also destroyed and, as there is a temperature rise of 5-10°C across the lamps, high humidity does not harm the system. The catalyst also provides a buffer function and allows handling of high and rapid variances in inlet concentrations. The outcome is an exhaust air, free of wastewater odor which may be released directly into the environment.

**Photo Ionization Advantages**

Photo ionization technology has a number of advantages over chemical and biological scrubbers:
- No water or chemicals are required for treatment and effluent is not produced
- Only electricity is required for operation of the odor control plant
- Unlike biological scrubbers, there is instant response to variations in the concentration of odorous species in inlet gases
- Photo ionization plants work without any significant local control (UV lamps are not modulated but are on or off in accordance with the ventilation fans, but may be connected and controlled by a SCADA system)
- There is no significant daily, weekly or monthly maintenance required and usually only an annual replacement of filters, UV tubes and the catalyst. (Usually only one day is required to complete the maintenance; and catalyst maintenance requirements are minimal in comparison with activated carbon scrubbers)
- The plant operates fully once it is turned on and the scrubber reaches equilibrium almost immediately
- Units are modular and can be built up in capacity to suit the odor source
- The scrubber has a very small footprint, and can be located alongside the odor source
- Since there is no residual wastewater odor, only a stub stack is required
- UV light provides extensive disinfection as a secondary effect

Much of the success of this technology is found in the ease of the process. Photo ionization is a “switch on/switch off” technology with very limited control demand. The technology does not make any demands regarding raw gas conditions.

The limited operation and control demand of photo ionization combined with its high treatment efficiency represents ideal prerequisites for treatment of wastewater odors. The photo ionization plant can also be combined with a silencer on the exhaust stack to provide, literally, whisper-quiet operation. Because there is no wastewater odor in the exhaust gas, the plant doesn’t require ducting to a central tall stack.

**Water Corporation’s Use of Photo Ionization**

Water Corporation is commissioning a 20 ML (megaliter) per day Stage 1 Waste Water Treatment Plant (WWTP) at Alkimos, in the northern suburbs of Perth, Australia. It has been designed and constructed by the Alkimos Water Alliance, a partner of Water Corporation. During design, the Alkimos Water Alliance opted to consider photo ionization for Stage I odor scrubbing of the foul air vented from the inlet works as a recommendation of its technical consultant. The Water Corporation was asked to consider use of this technology by the Alliance, and did so on the basis of three technical assessments.

**Site Visit Assessment:** As part of the process to evaluate the technology, representatives were sent to view operating odor scrubbing plants in Germany and Dubai. The odor plants viewed in

**Table 2. Details of Performance of Various WWTP Photo Ionization Scrubbers**

<table>
<thead>
<tr>
<th>No.</th>
<th>Plant</th>
<th>Capacity (m³/h)</th>
<th>H₂S (ppm)</th>
<th>Odor (OU/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>In</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>1</td>
<td>Palm Jumeirah STP</td>
<td>57,000</td>
<td>n.m.</td>
<td>n.m.</td>
</tr>
<tr>
<td>2</td>
<td>Freising, Sludge handling facility</td>
<td>1,500</td>
<td>n.m.</td>
<td>n.m.</td>
</tr>
<tr>
<td>3</td>
<td>Mindelheim STP</td>
<td>12,000</td>
<td>n.m.</td>
<td>n.m.</td>
</tr>
<tr>
<td>4</td>
<td>Tubli, Bahrain, Pilot Thickener</td>
<td>250</td>
<td>56</td>
<td>n.d.</td>
</tr>
<tr>
<td>5</td>
<td>Subiaco, Pilot Influent channel</td>
<td>250</td>
<td>77</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

n.d. = not detected; n.m. = not measured
Germany were at WWTPs at Freising, Kaiserslautern, Mindelheim and Moorsburg. In Dubai, the WWTP was located at Palm Jumeirah, and the sewage pump station at Al Warqa’a. Most odor scrubbing units in Germany were relatively small except for Mindelheim, where the odor scrubber was designed for 12,000 m$^3$/hr, similar to Alkimos. At Palm Jumeirah WWTP, the unit is designed for 57,000 m$^3$/hr. All of the plants demonstrated very similar features, including being quiet, unobtrusive and extremely effective in removing wastewater odor.

**Pilot Plant Assessment:** A trial was established at Subiaco (Australia) Wastewater Treatment Plant (WWTP) utilizing a Neutralox manufactured pilot plant, beginning the morning of June 8, 2009, and was operated continuously over a three-week period. The pilot plant consists of a 304 stainless steel housing segmented into chambers for the dust filters, UV lamps, catalyst, fan and simple control panel. Its only connections are the inlet gas and electrical power. The pilot plant was installed over the inlet channel, in front of the pre-treatment building of the WWTP. A total of 63 ML/d of wastewater is received from essentially commercial and residential properties, with Subiaco WWTP located west of the Perth City CBD. Flows of wastewater into Subiaco WWTP are quick because of the small nature of the catchment. Pre-testing at the site immediately prior to the trial showed that H$_2$S readings were in the range of 15 to 40 ppm.

The air flow rate of the pilot unit is adjustable, and for the duration of the trial, the air flow rate was maintained at approximately 220 m$^3$/hr. The air flow rate was calculated by measuring the air velocity on the inlet and outlet of the pilot unit by use of an anemometer.

For ease of transport and use, the pilot plant has two linear stages, with the UV lamps in the first two compartments and the catalyst in the next.

### Table 3. Odor Substances Measured Using Draeger Tubes June 8, 2009 and June 9, 2009

<table>
<thead>
<tr>
<th>Time</th>
<th>Substance</th>
<th>Range</th>
<th>Inlet</th>
<th>Outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.06.2009</td>
<td>(CH$_3$)$_2$S</td>
<td>Ppm</td>
<td>34</td>
<td>n.d.</td>
</tr>
<tr>
<td>01:20 pm</td>
<td>H$_2$S</td>
<td>Ppm</td>
<td>14 and 22</td>
<td>n.d.</td>
</tr>
<tr>
<td>09.06.2009</td>
<td>(CH$_3$)$_2$S</td>
<td>Ppm</td>
<td>22</td>
<td>n.d.</td>
</tr>
<tr>
<td>8:30 am</td>
<td>H$_2$S</td>
<td>Ppm</td>
<td>40-60</td>
<td>n.d.</td>
</tr>
<tr>
<td>09.06.2009</td>
<td>Mercaptans</td>
<td>Ppm</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>01:00 pm</td>
<td>(CH$_3$)$_2$S</td>
<td>Ppm</td>
<td>40</td>
<td>n.d.</td>
</tr>
<tr>
<td>09.06.2009</td>
<td>H$_2$S</td>
<td>Ppm</td>
<td>&gt; 20</td>
<td>n.d.</td>
</tr>
<tr>
<td>01:00 pm</td>
<td>Mercaptans</td>
<td>Ppm</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>Ammonia</td>
<td>Ppm</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

n.d. = not detected

In addition, odor samples were analysed during commissioning of a new bioscrubber at Woodman’s Point (Subiaco) WWTP. These results are shown in Table 4.

**Results Described**

The OdaLog, a portable gas detector, used on the inlet (raw gas) of the pilot unit showed H$_2$S readings in the range of 20 to 50 ppm. The loading concentrations vary, which is typical for pump stations and inlet structures. Grab samples of other potential odor substances have been taken with Draeger tubes, a brand of short-term gas detectors. Such sampling is not necessarily highly accurate, but gives an indication of the type and proportion of other odor substances.
Before the variation in the odor load, the grab sample results should not be overvalued. Dimethyl sulfide has been measured with pre-filter tubes to cross sensitivities with H₂S.

On the outlet (clean gas) of the pilot, neither the OdaLog nor the Draeger tubes showed any concentrations. Considering the odor thresholds of the respective substances (Table 1) these results should not be overvalued either. A lack of detection does not necessarily mean that odor is not present. To evaluate odor concentration, an odor analysis is beneficial. The readings of the odor samples from the pilot outlet are quite low at 151 to 181 OU/m³. That dilution takes place from the outlet stack to the boundary fence should also be considered.

Normal background odors such as those from traffic, vegetation, grass mowings, etc., can provide background odor concentrations from 5 to 60 OU/m³ or more (DEFRA 2010).

The air temperature increased by more than 10°C from the inlet to the outlet as it passed over the UV lamps. This temperature increase removes the risk of precipitation inside of the unit, even when receiving 100 percent humidity at the inlet of the plant.

**Alkimos Wastewater Treatment Plant Scrubber Assessment**: The Alkimos Water Alliance evaluated the photo ionization scrubber offer along with a large number of bioscrubber tenders, and eventually selected photo ionization over the biological technology. The photo ionization scrubber was far less than the bioscrubbers in terms of capital cost, and slightly more than the bioscrubbers in NPV (net present value). (Details of the capital and operating costs are currently deemed commercial in confidence.) This, plus the due diligence on the technology undertaken by the Alliance as part of the tender assessment process, enabled the photo ionization scrubber to become the preferred option for the Alliance. The Alliance proposed that the Neutralox photo ionization scrubber be accepted as the odor scrubbing option for the new Alkimos WWTP, and the Water Corporation accepted.

The plant is designed for treatment of up to 15,000 m³/h, and a minimum of three photo ionization units can handle the total airflow rate. This allows for redundancy and the opportunity to replace consumables on single units, while the plant as a whole remains in operation. This arrangement is in place of two bioscrubbers, in a duty/standby arrangement, and should allow cost savings over the life of the scrubber. As there are no moving parts involved in the technology, and because the treatment operates over a range of environmental conditions, the likelihood of breakdown is minimal.

For the scrubber outlet, Neutralox has guaranteed a maximum odor concentration of 500 OU/m³ and a 99.5 percent reduction in H₂S. Maintenance is predicted to be limited to eight man-hours per unit per year for replacement of consumables, including dust filters, UV lamps and activated carbon.

The photo ionization units were shipped to Perth in January 2010. Set-up and complete installation of the photo ionization plant was completed in two days. Installation of fans and ductwork was undertaken separately. The scrubber was pre-commissioned on August 16, 2010. The Alkimos Wastewater Treatment Plant, including the scrubber, is currently in commissioning, which is to be finished in mid-November.

Unfortunately for this report, progress in commissioning has not yet reached the odor scrubber. As of October 11, 2010, the photo ionization scrubber is in service and receiving odorous gas. However, not all sources are connected, and inlet H₂S level has only been in the order of 4 ppm. There is no H₂S detected on the scrubber outlet. Inflows to the plant are at 7 ML/d.

Controlling odors at wastewater treatment plants and within collection systems is a growing concern. Conventional technologies exist, but do not always provide for the most cost effective solution. Photo ionization is a new technology that uses well established operating principles. It can provide a long term, cost effective solution that minimizes the operational costs associated with odor control.

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**Resources**

WEF 2004, Control of Odors and Emissions from Wastewater Treatment Plants, Manual of Practice 25, Water Environment Federation, Alexandria, VA, USA.


DEFRA 2010 Odor Guidance to Local Authorities, Department for Environment, Food and Rural Affairs, Nobel House, 17 Smith Square, LONDON SW1P 3JR.