TRAINING AND OPTIMISATION – INSEPARABLE BEASTS

1.0 INTRODUCTION

When considering wastewater treatment, what is optimisation? In this context, generally optimisation is considered to be either reduced operational costs, or reduced risk of process failure. Either way, optimisation of wastewater treatment plants (WwTP's) requires employees who understand the role of the WwTP in the overall site, and the mechanisms behind the various treatment processes. For many industries, this will require upskilling of employees, not only those who have direct involvement with the WwTP, but all employees who have the potential to impact on the performance of the treatment processes.

As a primary producing nation, New Zealand has many "wet" industries which produce large volumes of highly concentrated wastewater. This includes the dairy processing, meat and poultry processing, and pulp and paper processing industries. Whether industries are treating the wastewater themselves or discharging to the municipal sewer system through trade waste agreements, increasingly stringent resource consent conditions and public expectations require higher levels of wastewater treatment. As a result, treatment plants are becoming more complex, costly to operate, and have a higher risk of failure. For many industries, wastewater treatment represents a distraction from their core business, however it should be viewed as an opportunity. Treatment plants run by skilled Operators can be optimised to run more efficiently, reducing both operational costs and risks of process failure.

2.0 INDUSTRIAL WASTEWATER

The characteristics and volumes of domestic wastewater are largely predictable and consistent. This, combined with a good balance of nutrients, makes domestic wastewater relatively simple to treat. Wastewater from wet industries can be particularly challenging to treat for many reasons, including variable flows and loads due to diurnal and seasonal changes, high strength wastewater, readily biodegradable wastewater, the presence of toxic compounds, and nutrient deficiency. The treatment processes used to treat municipal wastewater are generally still relevant when treating industrial wastewater, but the nature of the wastewater does present specific challenges. It is necessary to understand these challenges to be able to effectively manage them. To understand these challenges requires an understanding of the treatment processes themselves.

3.0 CHANGES IN TREATMENT TECHNOLOGIES

Treatment of industrial wastewater, either in isolation or combined with municipal wastewater, is often achieved using pre-treatment technologies such as dissolved air flotation (DAF) and anaerobic lagoons, and variations of the activated sludge process, such as moving bed bioreactors (MBBR), sequencing batch reactors (SBR), aerated lagoons, and biological nutrient removal (BNR) processes. These technologies, and some challenges of treating specific industrial wastewaters, can be briefly described as follows.

3.1 Dissolved Air Flotation

DAF processes float light particles to the surface through the release and rise of tiny air bubbles. This principle is simple, and many wastewaters can be pre-treated in this way. However, it is easy to operate a DAF process inefficiently. DAF treatment of many industrial wastewaters requires chemical addition to coagulate and/or flocculate fine or dissolved solids into flocs which will readily rise to the surface. In many cases, it may also be necessary to adjust the pH of the wastewater to maximise contaminant removal. Coagulants such as ferric sulphate or aluminium sulphate, polymers, or acids and alkalis, are costly. Under-dose, and the performance of the process will quickly drop. Over-dose, and money is effectively being thrown away and may also lead to deteriorating process performance.

The sludge, or “float”, that must be removed from the surface of the DAF plant is also important to consider. In many cases, the sludge will be tankered off site for disposal in which case sludge dry solids (DS) concentration can significantly impact the volume, and therefore cost, of sludge disposal. While the sludge may readily float to the surface of the DAF, optimising the DS concentration of the sludge can be more challenging as many operating factors will affect the sludge characteristics. This includes chemical dosing, quantity and size of air bubbles, sludge depth, and scraper sequencing.

3.2 Anaerobic Lagoons

Anaerobic lagoons are often used to pre-treat high strength wastewaters, such as meat processing wastewater. The main advantage of anaerobic lagoons is the reduced operational costs compared with aerobic processes, with the potential to recover energy in the form of methane gas. Depending on what processes are being used downstream to polish the effluent prior to discharge, anaerobic lagoons can create significant treatment issues. By nature of the process, anaerobic lagoons will break down the organic carbon in the wastewater, but the concentration of total nitrogen and total phosphorous will remain relatively unchanged. This results in a pre-treated wastewater which is low in carbon and high in nutrients, the problem of which will be discussed in the following section. Anaerobic lagoons can also be challenging to operate, particularly if the wastewater load is inconsistent.

3.3 Activated Sludge Processes

Generally an activated sludge based process will be required to produce a final effluent quality which meets current, increasingly stringent, resource consent requirements. The activated sludge process, or variations such as MBBR, SBR, or BNR, relies on a “biomass” of aerobic microorganisms to break down pollutants in the wastewater and convert the pollutants into more biomass. This biomass will then readily settle as flocs in the clarifier or settlement stage, allowing treated effluent to weir over from the top of the clarifier.

While activated sludge processes are robust, many problems, such as filamentous bulking, can be encountered. This can cause poor settlement, high suspended solids in discharged effluent, and washout of biomass from the process. Such problems are more likely when treating industrial wastewater due to the wastewater characteristics already discussed. To minimise the likelihood of such problems occurring, or to resolve the issues if they do occur, the biology of the process must be understood. The operating conditions of the process will affect performance, with the Operator needing to control parameters such as dissolved oxygen (DO), sludge age, and nutrient availability. Two common activated sludge process problems associated with treating industrial wastewater, as revealed under a microscope, are shown in Figures 1 and 2 below.

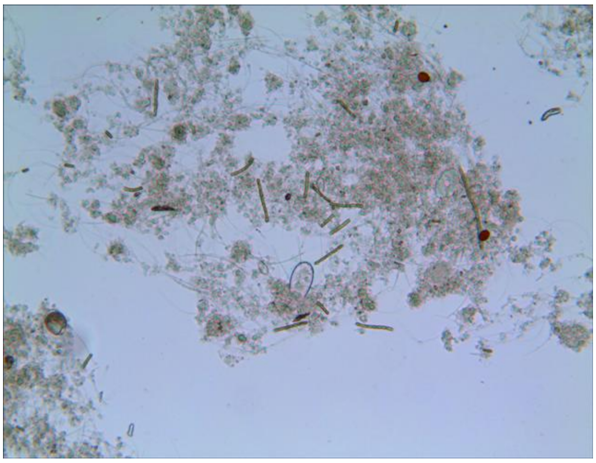

Figure 1: Filamentous bulking (x100 magnification)

Excessive growth of filamentous bacteria can result in “bridging” from one floc to the next. This increases the surface area of the floc, meaning the floc will settle more slowly. In severe cases, this can result in suspended solids carry-over from the clarifier. There are many different types of filamentous bacteria, with their growth encouraged by a range of conditions. This includes low DO, high organic load, and nutrient deficiency.

Figure 2: Dispersed bacterial growth (x100 magnification)

If dispersed bacterial growth occurs, fine suspended solids which do not readily settle will wash out from the clarifier. Causes of dispersed bacterial growth include nutrient deficiency, temperature changes, and high organic load.

Treatment of wastewater with a poor nutrient balance can result in both filamentous bulking and dispersed bacterial growth. Typically for every 100kg of carbon in raw wastewater, 5kg of nitrogen and 1kg of phosphorous are required to effectively treat the wastewater aerobically. Conversely, if there is insufficient carbon present, this can affect the denitrification process (conversion of nitrate to nitrogen gas), resulting in high effluent nitrate concentrations in discharged effluent. While this can be overcome by addition of supplementary carbon such as acetic acid, methanol, or ethanol, this is a costly process.

4.0 OPTIMISATION CASE STUDIES

For commercial reasons, most industrial sites are secretive about their inner workings for fear of divulging secrets and handing their competitors an advantage. To protect this, the following case studies are not specific case studies, but are intended to provide examples of how industrial wastewater treatment plants can be optimised to reduce either operating cost and/or risk.

4.1 Milk Processing

Milk processing wastewater is commonly pre-treated by a DAF process, and the resulting sludge is often trucked away and spread onto farmland. If, say, 72m^3 per day of sludge at 5% DS is produced, costing \$25/m^3 for transportation and disposal, the cost of sludge transportation and disposal is in excess of \$650,000 per annum. Increase the sludge DS to 10%, and more than \$300,000 per annum can be saved in sludge disposal costs alone.

4.2 Meat Processing

Meat processing wastewater is commonly pre-treated by an anaerobic lagoon, before being further polished using an activated sludge based process. The anaerobic lagoon breaks down the organic matter, but not nutrients, meaning the wastewater entering the aerobic process is high in nutrients and low in carbon. If low effluent total nitrogen concentrations must be achieved to meet resource consent or trade waste conditions, supplementary carbon dosing will be required. While it may be possible to provide this supplementary carbon by bleeding part of the raw wastewater directly into the activated sludge plant, this becomes difficult to control and risks breaching resource consent or trade waste limits.

4.3 Pulp & Paper Processing

Pulp and paper processing wastewater is traditionally very nutrient limited. Activated sludge based processes are being more commonly used to treat such wastewater in New Zealand. If the organic load to the treatment plant is 10 tonnes per day, then 0.5 tonnes of nitrogen and 0.1 tonne of nitrogen would be required to ensure adequate nutrient balance for activated sludge treatment. This would cost approximately \$300,000 per annum for nitrogen dosing in the form of urea, and \$600,000 per annum for phosphorous dosing in the form of phosphoric acid. If the processes are not sufficiently understood and nutrients are overdosed by 10%, the additional cost would be close to \$100,000 per annum. Conversely, if insufficient nutrients were dosed, the final effluent quality would likely be compromised due to filamentous bulking, dispersed bacterial growth, or other biomass-health related issues.

5.0 TRAINING

Why do industries invest in training staff? Many reasons could be quoted, such as improving the safety of employees, increasing staff retention through development opportunities, reducing the risk of mistakes being made, and increasing productivity. The bottom line, however, is that companies invest in training because it is financially beneficial to do so. Providing training for staff to understand WwTP's is no different. Skilled Operators can reduce the risk of treatment process failure and optimise processes to reduce operating costs, but training should not just focus on employees directly involved with the operation of the WwTP.

What training needs to be provided to offer value for money for an industrial employer? While qualifications can be useful, they are not the panacea. Training should be considered on a site by site basis, and the potential impact of all staff on the WwTP should be considered when developing a training plan. Irrespective of the nature of an industrial site, all employees can directly affect the cost of treatment and process risk of the WwTP. For example, an employee who washes a spill down to the site sewer could potentially kill the WwTP if the spilled material is toxic, or would add to the wastewater load if the spilled material is product of some kind. A multi-million dollar treatment plant provides no protection against ignorant employees.

On the majority of industrial sites, the Operators responsible for water and/or wastewater treatment also perform a range of other duties. As treatment plants become more complex to meet increasingly stringent effluent quality requirements, these Operators are often expected to pick up additional workload and skills. Just because Operators are excellent boiler men or maintenance fitters doesn't mean they will make good treatment plant Operators, particularly if it is not something that interests them. Therefore, consideration should be given to employing specialised staff to operate the treatment plants.

To allow Operators to optimise WwTP processes, and reduce the risk of process failure, Operators need to understand the wastewater characteristics and treatment processes on the particular site. Sounds obvious, doesn't it? In many cases, the most effective training for industrial WwTP Operators may be process- and even site-specific, developed for an individual site, and even held on-site to allow concepts learned in theory to be directly applied on site. However, for this to be effective, some more general background knowledge will also be required. This may include chemistry, physics and maths for operation of a DAF, and microbiology and maths for operation of an AS-based process.

So if site-specific training can provide the skills the Operator needs to optimise the treatment processes and reduce the risk of process failure, why bother investing in qualifications? Qualifications can provide recognition for the Operators skills against a nationally-recognised qualification, which can provide a career development pathway either within the industry or outside. This can assist with retention of staff who feel valued, reducing the cost and risk associated with training new staff. There is a shortage of wastewater treatment plant Operators in New Zealand, so the value of such skilled staff should not be underestimated.

6.0 CONCLUSIONS

In comparison to treating domestic wastewater, industrial wastewater is relatively hard to treat. As resource consent and trade waste conditions become more stringent, increasingly complex wastewater treatment processes are becoming more common on industrial sites. Treatment plants may be seen as a distraction from the core business of the industry, but are in fact a critical component. A technical treatment plant designed to meet stringent consent conditions represents a significant risk to the industry, both in terms of operating costs and in meeting resource consent or trade waste conditions.

To effectively and efficiently operate a treatment plant, it must be well understood. It is important for industries to recognise the role the WwTP has in the success of the business, and ensure that all employees are appropriately trained. A multi-million dollar WwTP provides no defence against ignorant employees, so all staff should understand the role and limitations of the plant. At the next level, the WwTP Operators should be provided with the training to really understand the processes they are operating. Skilled Operators can reduce the cost of running treatment plants through optimisation, and can reduce the risk of process failure.

Note: The views and opinions expressed are those of the Author, and do not necessarily represent the views of Opus Environmental Training Centre.