GOOD OPERATORS ARE HARD TO FIND: THE VALUE OF SKILLED OPERATORS

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ABSTRACT

Within a single generation, the sophistication of wastewater treatment plants (WwTP's) in New Zealand has taken a giant step forward. Historically, wastewater from the majority of New Zealanders was treated by low technology processes such as oxidation ponds or trickling filters. Activated sludge (AS) based treatment processes, which are more complex, are now by far the most common type of treatment process by population served.

Operators responsible for oxidation pond and trickling filter plants undertake mainly basic routine maintenance and site housekeeping, and have little influence over the performance of the treatment process on a day-to-day basis. AS processes are more complex and dynamic, and the Operator has much greater influence over the performance. The Operator needs to understand the treatment processes to be able to operate them efficiently and effectively, and reduce the risk of process failure.

The skills required by todays Operator are quite different from their predecessors. All those involved in the Industry, from Regional Council Resource Officers, Local Authority employees involved in decision making, Consultants advising Local Authorities, through to designers and suppliers of treatment plants, need to understand this changing role of the Operator. When WwTP's are upgraded, more emphasis must be placed on upskilling of Operators, and providing them with the tools they need to undertake their new role.

A skilled Operator can reduce the operating cost of a WwTP, allow capital expenditure to be deferred by optimising the plant, and reduce the risk of consent non-compliance and the adverse media and public scrutiny that follows such an incident.

KEYWORDS

Skilled Operator, Risk Management, Process Optimisation, Training

1 INTRODUCTION

Wastewater treatment in New Zealand is moving from infancy into middle age. When wastewater treatment plants (WwTP's) were initially installed in towns and cities throughout the country, processes such as oxidation ponds or trickling filters were generally used. Such processes are low technology, requiring Operators who undertake mainly manual or routine tasks such as maintenance and site housekeeping. As New Zealanders become more aware of the impact of wastewater discharges on the environment and towns and cities grow, many WwTP's are being upgraded or replaced with more complex treatment technologies to produce higher quality effluent.

Oxidation ponds are being replaced with variations of the activated sludge process, such as Sequential Batch Reactors (SBR), Membrane Bioreactors (MBR), and Biological Nutrient Removal (BNR) processes. Where the Operators were used to relatively passive treatment processes, they are now faced with more dynamic processes and increased regulatory scrutiny. The decisions Operators make can influence the process performance, the final effluent quality, and the cost of treatment.

2 CHANGING TECHNOLOGIES

2.1 RESOURCE CONSENT DRIVERS

In the early years of sanitation, the primary focus was moving the wastewater away from areas of habitation to reduce the risk of disease. Many towns and cities were reticulated, with raw wastewater simply being diverted to the sea or watercourse that was considered to have adequate dilution available to mitigate pollution. The mantra "The solution to pollution is dilution" was commonly accepted.

Times have changed, and now all discharges from WwTP's require a resource consent under the Resource Management Act (RMA). As New Zealanders become more aware of the need to protect the environment, the resource consent conditions are becoming more onerous.

In many cases low technology treatment processes such as trickling filters and oxidation ponds cannot achieve the discharge quality stipulated by the resource consent conditions. Many consents require reliable performance throughout the year, whereas the performance of trickling filters and oxidation ponds is seasonally affected. While satisfactory performance may be achieved from these technologies during the warmer summer temperatures, performance typically drops off during colder winter months, particularly with respect to nitrogen removal. More intensive treatment processes, such as variations of the AS process, can meet a consistent final effluent quality all year round provided they are well monitored, maintained and operated.

2.2 LAND AVAILABILITY

Historically, land was cheap and readily available in New Zealand. Therefore large footprint treatment technologies, such as oxidation ponds and, to a lesser degree, trickling filters, could be installed. Not only was the space available for such processes, the WwTP's could be hidden away in remote locations, with little concern that members of the public would be inconvenienced by the occasional smell.

As the population has grown in many towns and cities, the price of land is at a premium, and residential developments have edged closer to many treatment plant sites. Closer, less tolerant neighbours now demand strict odour conditions to be met. Treatment plants need to treat the wastewater from this higher population, but in many cases land is not available or is too expensive to purchase. It is therefore necessary for WwTP's to evolve on existing sites, utilizing treatment processes which require less space. Again, this forces the upgrade or replacement of old lower technology WwTP's with more intensive processes.

2.3 PROCESS COMPLEXITY

So, through a combination of the requirement to treat larger volumes of wastewater, to consistently improve the quality of treated effluent, but with less space available in which to do it, it has been necessary for treatment processes to evolve. While some oxidation pond and trickling filter processes are being modified to increase treatment capacity and improve treated effluent quality, many such technologies are being discarded in favour of activated sludge (AS) based processes, often followed by filtration and disinfection.

This trend can be seen in Figure 1, showing the primary method of BOD removal at municipal WwTP's in 1986, and those used in 2011. WwTP's serving populations of less than 1,000 have not been included in this summary, to allow comparison with the work of Fitzmaurice (1987). While many of the smaller towns (<1,000 population) are served by oxidation ponds, an increasing number are also using more advanced treatment technologies, such as MBR's used at Tirau, Tahuna, and Kawakawa Bay, and SBR's at Motuoapa and Kinloch. In 1986 there were 159 WwTP's each serving a population of at least 1,000, increasing slightly to 163 in 2011.

Again to allow comparison with Fitzmaurice (1987), the data is shown in Figure 2 by total population served. Once again, only treatment plants serving at least 1,000 people have been included in this summary.

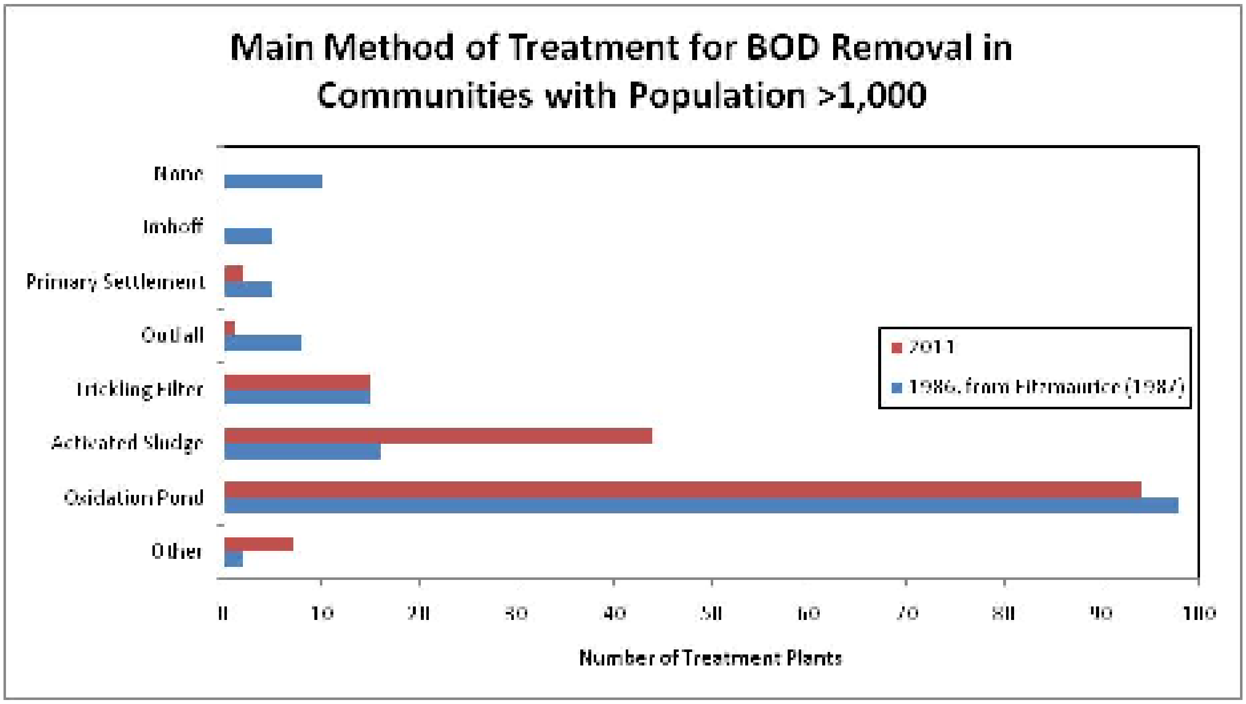

Figure 1: NZ Wastewater Treatment Technologies, by Number of WwTP's

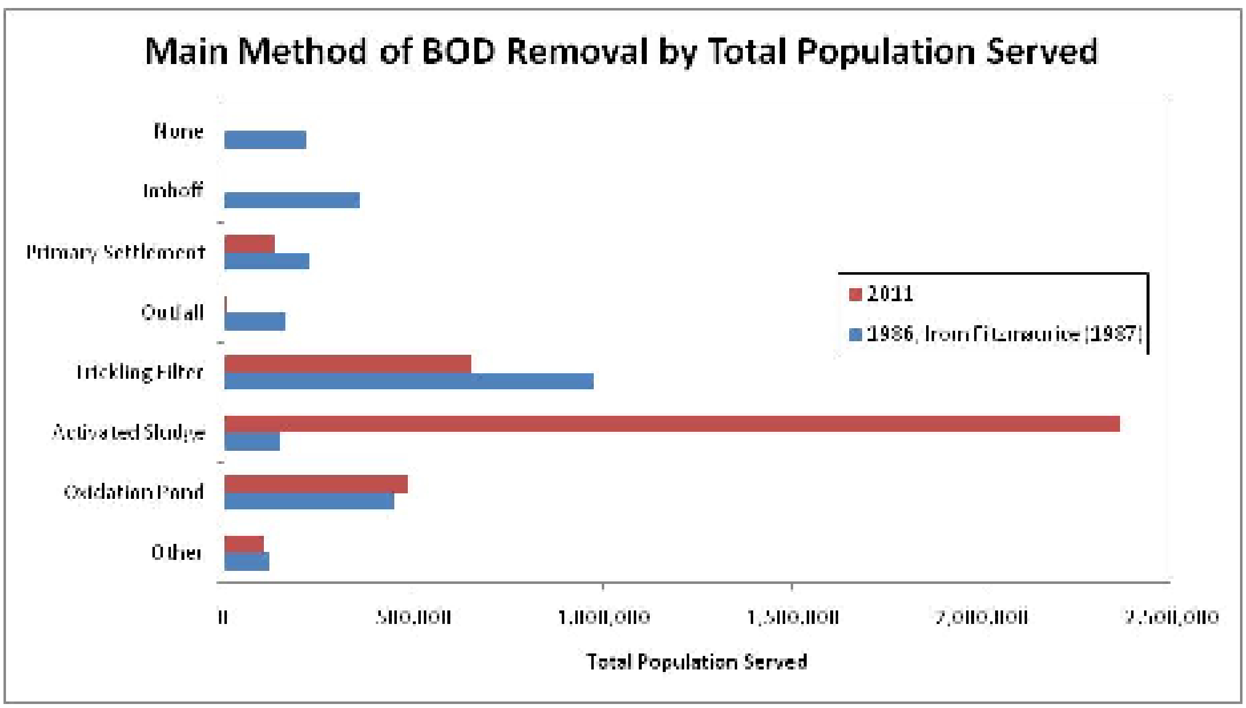

Figure 2: NZ Wastewater Treatment Technologies, by Population Served

The main change evident in Figure 1 is the increase in AS based processes, from 16 WwTP's in 1986 to 44 in 2011. However, even with this significant shift in treatment technologies, the data presented does not tell the full story. Many WwTP's which have been included under the "Oxidation Pond" banner are far more complex than a simple oxidation pond. Aerated lagoon processes have been included as a form of oxidation pond, but this grading does not do justice to the complexity of some aerated lagoon WwTP's such as Palmerston North which has seasonal chemical dosing for phosphorous removed, ultra-violet (UV) disinfection, and anaerobic sludge digestion. Similarly, several oxidation pond processes have been modified to increase capacity or improve effluent quality, such as membrane filtration at Dannevirke, Hikurangi and Matamata, and Induced Air Flotation (IAF) at Waihi. Such processes increase the complexity of operation, but the plants still fall into the Oxidation Pond category in this analysis. In addition, many industrial sites are now utilizing AS based treatment processes, with such treatment technologies commonly employed in the dairy processing, meat processing, and pulp and paper mill industries. Industrial sites have not been included in this data.

This shift towards AS processes can be seen more clearly in Figure 2. In 1986, 150,000 people were served by WwTP's with AS processes. By 2011, this has increased to in excess of 2,000,000. While this is skewed by the population of Auckland being served by AS plants at Mangere and Rosedale, wastewater from nearly one million New Zealanders living outside of Auckland is also treated by AS processes.

2.4 OPERATING COST

One of the many attractions of oxidation pond and trickling filter processes are the low operating costs. Ponds utilize algae to provide the oxygen required by aerobic bacteria and other microorganisms, while tricking filters are passively aerated by natural air flow through the media and from sprinkling wastewater across the top of the media. There are few, if any, moving parts, so there is little the Operator can control, and relatively simple maintenance tasks to undertake.

More complex treatment processes come at a cost. The cost of electricity for aeration, maintenance of equipment, analysis of samples for additional process monitoring, chemicals used in the treatment process, and the cost of employing and training Operators who understand the treatment processes. It is vital that this cost is understood, acknowledged and budgeted for by all parties involved in making decisions on WwTP upgrades or renewals. From Regional Council Resource Officers and Commissioners involved in setting resource consent conditions, Local Authority and Industry employees involved in decision making, Consultants advising Local Authorities and Industries, through to designers and suppliers of treatment plants. The cost of operating these more complex treatment processes should not be underestimated, but often is. If a Consultant advises a Client that only two hours per day of Operator time is required, then this is what will be budgeted for. The reality could well be quite different to be able to operate the plant effectively.

2.5 OPERATOR SKILLS

A "Good" Operator will be reliable, observant, proactive, and self-motivated. However, a Good Operator will not necessarily have the skills required to operate a more complex WwTP. It is vital that all parties acknowledge the increased skill level required for operating complex treatment processes. Operators responsible for oxidation pond and trickling filter processes undertake routine maintenance and site housekeeping. While they must also be observant so any sudden changes in the health of the process are noticed and reported, there is little that the Operator can do on a day-to-day basis to influence the performance of the process.

To effectively operate an AS process and variations such as MBR, SBR and BNR, the Operator requires a sound understanding of the biology of the treatment process, and return activated sludge (RAS) and waste activated sludge (WAS) must be managed to maintain the correct biomass levels. Environmental conditions in the AS process, such as dissolved oxygen (DO) and pH, must be monitored and maintained to ensure a healthy and stable microbiological population. Proactive process monitoring such as suspended solids, ammonia, nitrate and phosphorous requires on-site laboratory analysis to provide rapid results. Basic mathematics is a necessary evil to ensure the results of some tests are correctly calculated , and where chemical dosing is necessary an understanding of chemistry is also required.

It is not realistic to expect Operators who are used to oxidation pond and trickling filter technologies to be able to effectively operate a more advanced treatment plant with only a brief handover following commissioning and Operation and Maintenance (O&M) manuals to guide them. These Operators will need upskilling so they can fully understand the processes they will become responsible for, so they can be run efficiently and effectively. The cost and time required to effectively upskill Operators must be allowed for.

2.6 RISK OF FAILURE

More complex treatment technologies bring with them requirements of higher levels of treatment to meet both public expectations and resource consent conditions. It is no longer acceptable for poorly treated wastewater to be discharged into the environment, and any such transgression will be seized upon by the media. Public reaction to media coverage of such an incident can quickly turn a small incident into a public relations disaster.

Passive treatment technologies have low levels of risk. The expectations of the performance of an old Oxidation Pond system are relatively low, and there is very little that can go wrong providing the structure stays intact, the wastewater loading rates and characteristics do not differ too far from the design, and the ponds are desludged every decade or two. When complex treatment processes are working well the quality of the final effluent can be very high, but they can go spectacularly wrong if not controlled well.

Without singling out individual incidents, examples can readily be found in the media where environmental pollution, rightly or wrongly, is attributed to WwTP's. There is always likely to be a certain amount of finger-pointing towards treated effluent discharges, even when operating within the conditions of their resource consents. High profile incidents of WwTP failure highlight the risks of operating more complex processes, and the cost of such incidents can quickly add up. Not only is there the potential of Regional Council fines of up to $200,000, but many indirect costs that are harder to quantify, not to mention the damage to the reputation of an organization. Consider the time involved in dealing with the media, investigating incidents, reporting to management and Regional Councils, and attending incident response meetings.

3 THE ROLE OF THE OPERATOR

3.1 TREATMENT PLANT FUNCTION

The basic role of the Operator is to keep the WwTP functioning, and to contribute to a tidy and safe working environment. Maintenance and repair of mechanical equipment is necessary so pumps, aerators, blowers, motors, and other equipment will run when required. Such maintenance and repair may be undertaken by the Operator, or they may act more as a Project Manager, bringing in external resources to maintain specialist equipment. While this is a critical part of the role of the Operator and should not be underestimated, the responsibilities and actions are very clear; if a pump is broken, fix it! However, if all of the mechanical equipment is functioning, it does not necessarily mean that the treatment processes will be working effectively or efficiently.

3.2 PROCESS OPTIMISATION

Oxidation ponds and trickling filters are passive treatment processes requiring relatively simple maintenance. The Operator undertakes visual monitoring to gauge the health of the processes. There is little that an Operator can actually control, and the performance of the process is influenced more by seasonal factors than the actions of an Operator on a day-to-day basis.

In contrast, AS processes are dynamic. Conditions need to be suitable for the soup of microorganisms to live, breathe and degrade the polluting material in wastewater. The Operator must ensure there is adequate DO available, the correct amount of microorganisms (biomass), appropriate pH, and the right types of microorganisms present. This requires more intensive monitoring to provide the quick data necessary to proactively control and optimize the process.

Modifications to the AS process, such as SBR, MBR, and BNR, further increase the complexity and provide the Operator with more choices to make. In an SBR the cycle times and operating conditions need to be adjusted to optimize the treatment process for changing influent flows and loads. An MBR process uses expensive membranes to separate solids from the treated effluent, and the limitations and maintenance requirements of these membranes need to be understood. Where a resource consent contains strict nitrogen and/or phosphorous conditions, the Operator must understand how to manipulate process conditions to remove these nutrients, or, in the case of phosphorous, potentially dose chemicals.

While there are many examples where a skilled Operator can optimize treatment processes, some examples are given later in Section 4.

3.3 RISK MANAGEMENT

As with anything, if a treatment process is not properly understood or monitored, it cannot be managed effectively. While alarms can be set-up to alert the Operator of a problem, in many cases by the time the alarm has been generated, the damage has already been done or the process is difficult to turn around. A skilled Operator will be able to identify, and respond to, small changes in process operating conditions or performance, thus preventing a more serious process failure which could result in breach of resource consent conditions. They will also have a thorough understanding of the potential knock-on effects from one treatment process to the next, and how the WwTP can be best managed in the event of a non-routine incident. This is something that O&M manuals cannot fully cater for. A quick-thinking Operator can manage difficult situations while under stress, and in many cases prevent potential public relations disasters.

4 CASE STUDIES

4.1 PAUANUI

Pauanui WwTP was upgraded in 2007 from an aerated lagoon with maturation pond, to an IDEA (Intermittent Decant Extended Aeration) process. The resource consent conditions for Pauanui require low total nitrogen concentrations in the final effluent. Acetic acid dosing was included in the design for two reasons. Firstly, to provide a carbon source to assist the denitrification process. Secondly, the wastewater flow and load increases significantly for a very short period over Christmas and New Year, and the treatment process needs to be ready for it. In preparation, the second IDEA reactor is brought on line by dosing acetic acid to build up the biomass. The expectation at the time of design was that on average 0.081 tonnes of acetic acid would be required per megalitre (te/ML) of wastewater treated. Through the first couple of years of operation, the skilled Operators developed a sound understanding of the processes. In 2010/11, the average use of acetic acid was 0.026 te/ML. This represents a reduction in operating costs of approximately $55,000 per year compared with design.

4.2 TE AROHA

Prior to 2006, wastewater at Te Aroha was treated in facultative ponds. Towards the end of 2006, a MBR process was commissioned. As part of the design, soda ash dosing was included for pH correction, with the expectation that approximately $50,000 worth of soda ash would need to be dosed each year. In practice, the skilled Operators understood the role of pH in the treatment process, and were able to optimize the operating pH. Soda ash consumption was reduced to nil, thus saving approximately $50,000 per year compared with design.

5 CONCLUSIONS

Wastewater treatment technologies continue to evolve to meet increasingly stringent resource consent conditions while treating higher wastewater flows and loads on smaller footprint sites. In the past generation, New Zealand has experienced a significant shift towards more complex and more intensive treatment processes. Such processes require skilled Operators to ensure they run efficiently, meet resource consent requirements, and minimize the risk of process failure. It is necessary for all those involved in the wastewater industry to fully understand the implications of these changes. This requires up-skilling of Operators to understand more complex processes, and allow additional Operator time and resources to ensure more complex treatment processes are operated to their full potential.

ACKNOWLEDGEMENTS

Thank you to the many people up and down the country who provided information on the current status of treatment plants, and to the ladies at Opus' Information Centre for unearthing a little gem.

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