INVESTIGATING THE BENEFIT OF UTILISING FISH IN SEWAGE TREATMENT

Paper Presented by:

Ben Pohlner

Author:

Ben Pohlner, *Manager Aquaculture,*

Wannon Water

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Ben Pohlner, *Manager Aquaculture*, Wannon Region Water Corporation

ABSTRACT

Wannon Water has been undertaking a research and development project to determine the impact of fish on the accumulation of sludge in lagoon based sewage treatment plants. Trials have been underway for 7 years in partnership with Deakin University. Tank trials using primary effluent show fish can reduce the total volume of sludge up to 46% over 70 days. Full scale trials are now underway at Hamilton and Port Campbell Water Reclamation Plants (WRP's) to quantify the impact of fish in primary lagoon systems. This paper gives an outline of the research undertaken, what we currently know, and the potential for this innovative technology in the Water Industry.

1.0 INTRODUCTION

De-sludging sewage treatment lagoons is a costly and messy process, and can be a lengthy disruption to the operation of the sewage treatment facility. Reducing the frequency of de-sludging has the potential to lead to significant OPEX savings and potentially lower greenhouse emissions.

Wannon Water (in conjunction with Deakin University) have been trialling the use of fish as a method of sludge removal in lagoon based sewage treatment plants since 2009, and are now in the process of undertaking full scale trials in the Hamilton and Port Campbell sewage treatment facilities. This paper details the work undertaken to date on the use of fish to assist in the remediation of sludge, including the potential savings to the water industry.

Wannon Water regard this research as significant for the water industry as a whole. Subsequently, this paper provides all relevant outcomes of aquaculture research to date to inform the water industry. Wannon Water are seeking interested water utilities to help complete the research and implement this technology.

2.0 DISCUSSION

Developing new technology can take time, and understanding the potential of fish to improve sewage treatment processes is no different. The following is a brief history of the research undertaken by Wannon Water and others.

2.1 Getting Started: 2008-2010

Wannon Water initially became interested in the concept of using fish to improve sewage treatment through earlier work undertaken by the Victorian Department of Primary Industries. Their early work to demonstrate possible aquaculture production in wastewater lagoons concluded that:

- Key drivers for development of integrated aquaculture use of recycled wastewater exist at a regional, state and federal level.
- Key stakeholders for aquaculture use of recycled wastewater in Victoria include the federal government, Victorian state government, and regional water authorities.

- Major scientific and technical information gaps exist in relation to aquaculture use of recycled wastewater

Following a review of the DPI work in 2008, Wannon Water invited Deakin University to investigate the concept of aquaculture in sewage lagoons, and the organisations jointly developed a "Road Map" outlining the research required to get from concept to commercialisation. This Road Map has been extremely valuable and has enabled Wannon Water to take a strategic approach to R&D for integrated aquaculture in sewerage treatment lagoons.

Step 1 in the Road Map was to undertake a review of Wannon Water facilities to determine their suitability for aquaculture and to determine the location place to undertake research. Hamilton (Victoria) was chosen as the preferred site to undertake aquaculture research as the relevant licences and permits were able to be obtained, and the effluent quality was deemed suitable for the purpose.

A research facility was constructed on the banks of the Hamilton WRP primary lagoon and trials were set up to assess fish growth, sludge and water quality.

2.2 Establishing the Science: 2010 - 2013

Wannon Water has supported a number of Honours student projects at Deakin University to establish the basic science of using fish to improve the sewerage treatment process.

The initial project was to determine the impact of Goldfish (*Carassius auratus*) culture on Total Nitrogen (TN) and Total Phosphorous (TP) in primary effluent lagoon water. The trial also examined Goldfish survival at different stocking densities, and fish flesh was tested for accumulation of pesticides and heavy metals.

The early results showed very little impact on water quality including TN & TP concentration over the duration of the trial. No accumulation of heavy metals in fish flesh was detected. An extension of this trial also showed no accumulation of pesticides.

Fish were trialled at 3 stocking densities with high survival in all categories. Growth was also assessed and was directly correlated with stocking density – the lower stocking densities showed much faster growth.

One major point of significance was noted in this trial. Approximately 50 – 100mm of sludge accumulation was observed in the control tanks at the conclusion of the trial, however almost zero sludge accumulation was noted in the tubs containing fish.

This discovery was the inception of further research focusing on the potential for fish to reduce sludge volumes in sewage lagoons.

In an effort to identify a suitable native fish species for sludge remediation, a second Honours project was undertaken to assess a range of potential fish species including two species of Mullet, Silver Perch and Tench.

Figure 1: ***Control tank – No fish heavy sludge accumulation***

Figure 2: ***Tank with goldfish zero sludge accumulation***

These species were assessed for survival and their ability to remove sludge from the trial tanks. The results showed that there were no native species suitable for sludge remediation and that Goldfish were the best performers in the trial. These new trials also found a significant decrease in accumulated sludge in tanks with goldfish, confirming the earlier results.

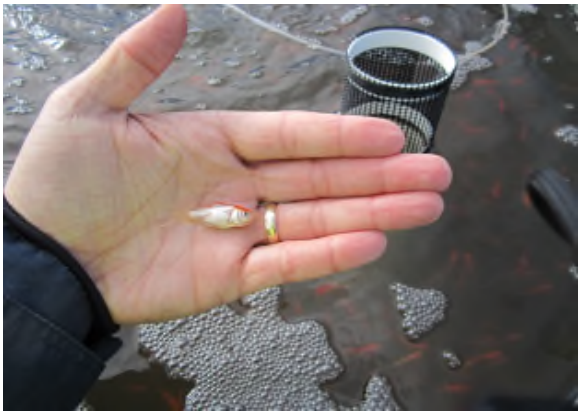

Figure 3: ***Goldfish at the time of stocking - trial tanks***

Figure 4: ***Goldfish after 5 months in primary effluent***

In 2012, a third Honours trial assessed the impact of Goldfish on a set volume of sludge in a static tank with no inflow or outflow. The trial used sludge and water directly from the Hamilton primary effluent lagoon.

Results over 70 days showed fish survival of 89 – 93% and rapid early growth. All treatments containing fish displayed significant decreases in sludge and treatments without fish showed very minor decreases that were not significant.

A Probiotic was also included in these trials as a comparison. The probiotic was promoted as being able to significantly reduce sludge volume by enhancing the natural bacteria populations in a sewage treatment system, and thereby significantly contribute to the decomposition of sludge.

Our results showed an average of 13.5% reduction in sludge volume when probiotic was used alone compared to Goldfish which recorded an average of 32.4% reduction in sludge volume. Of most interest was the combination of fish and probiotics which recorded from 37.6% to 46.2% reduction in sludge volume.

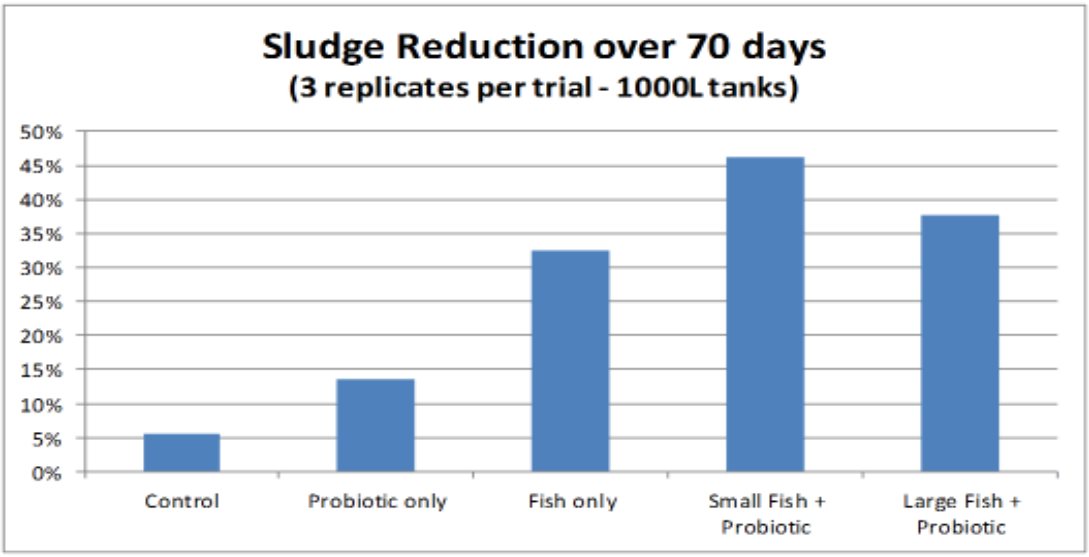

Figure 5: ***Sludge reduction over a 70 day period in static trial tanks***

This trial demonstrated that fish are very effective at removing solids; however utilising fish in combination with probiotics appears to be a more effective technique for sludge remediation.

2.3 Growing our own fish: 2013 - 2015

Based on the trial results, Wannon Water secured an unused commercial aquaculture facility in Warrnambool (Victoria) capable of producing up to 2M fry (young fish) annually. This facility is now producing goldfish specifically reared for sewage sludge treatment.

Wannon Water also invested in the development of a Juvenile Fish Production Facility in Hamilton. This involved the conversion of an obsolete biosolids drying bed facility comprising 16 cells. This facility is currently used to grow 15mm fry from the Warrnambool hatchery up to 50mm in size ready for stocking into operational sewage treatment plants.

2.4 Finding the ultimate sludge sucker - Goldfish x Carp hybrids

Common carp (*Cyprinus carpio*) are seen as superior to goldfish for the purpose of sludge remediation as they grow faster, grow bigger, and are able to tolerate extremely harsh water quality environments. Carp are classified as noxious and invasive in Victoria, meaning the biosecurity requirements for culturing carp would be so restrictive that any proposal to use them in sewage treatment could not practically proceed.

During 2013 Wannon Water investigated Goldfish x Carp hybrids which are cultured overseas as a food fish. This fish (when crossed correctly) has significant advantages over both carp and goldfish in that it grows faster and to a much larger size (15kg+). It is very hardy and able to tolerate very poor water quality conditions (much tougher than a both carp and goldfish). It also has enhanced disease resistance and it is almost sterile.

Deakin University undertook a literature review into the fertility status of Goldfish x Carp hybrids. This review found that male hybrids are sterile, however there is a slight chance that female hybrids may be fertile. It is not known if hybrids could develop a self-sustaining population in the wild if inadvertently released.

In 2015 Wannon Water received the appropriate DPI licences and commenced a program to breed goldfish x carp hybrids in Warrnambool to develop hatchery methods (in conjunction with a commercial hybrid hatchery in America). As a result of this work, successful spawning, larval rearing, and grow out of hybrids was achieved. Further work is now being undertaken to demonstrate acceptable levels of sterility using different larval rearing techniques in an effort to gain DPI approval to stock this fish in primary effluent lagoons.

2.5 Confirming this will work operationally - Hamilton and Port Campbell

Initial lagoon stocking using goldfish was undertaken at the Hamilton WRP in 2015/16 to investigate the impact on sludge on a full lagoon scale. Approximately 150,000 fish were raised by Wannon Water and stocked into the primary lagoon. The assessment of their impact is ongoing, with sludge surveys using novel sonar technology undertaken at 6 monthly intervals to determine impact on sludge volumes.

A more structured research trial was also recently implemented at the Port Campbell WRP. Port Campbell has a twin primary lagoon system, with influent distributed evenly between the two lagoons. One Primary lagoon at Port Campbell was stocked with goldfish to enable a direct comparison between the primary lagoons and the impact of fish on sludge volumes. Monitoring of fish and water quality is undertaken on a weekly basis, and sludge volume monitoring is undertaken on a 6 monthly basis. The trial will also assess overall treatment plant efficiency and any implications for EPA licencing.

To date this trial is going well, with sampled fish showing good growth and no symptoms of disease or stress. Fish are able to tolerate the primary effluent lagoon environment and have no impact on the daily operation of the facility. This trial is due for completion in mid-2017.

2.6 Potential for the Australian Water Industry

Wannon Water has estimated the financial benefits of using fish to reduce the rate of sludge accumulation within suitable water reclamation plants in South West Victoria. Whilst these estimates are encouraging, the potential is limited by the size and number of the primary effluent lagoons in the Wannon Water service area.

Extrapolating these estimates to an industry wide figure for Victoria indicates that the technology has the potential to reduce operating costs in the sector by many millions of dollars. Completing the current research phase of the project at Wannon Water is vital to properly quantify this potential.

3.0 CONCLUSION

Wannon Water's aquaculture research program has demonstrated that the use of fish to slow the rate of sludge accumulation in lagoon based primary effluent lagoons is possible and significant.

Tank trials show that fish actively reduce the rate of sludge deposition in primary effluent lagoons. Wannon Water is now undertaking full scale trials at Port Campbell and Hamilton to confirm the concept will work operationally. Wannon Water believe this research is significant to the Australian water industry, and are seeking interested water utilities to help finalise the research and implement this technology.

4.0 ACKNOWLEDGEMENTS

There are many people to thank who have contributed to this research. This includes the Wannon Water Aquaculture Team, the Wannon Water Board and Management, Wannon Water Treatment Operators, Deakin University Researchers, Lecturers, and students.

5.0 REFERENCES

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