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Global Solutions

A COMMERCIAL APPLICATION OF VIROSOIL™ TECHNOLOGY

CASE STUDY
TOMEI PRAWN FARM

"The Virotec treated pond has yielded a rate of around four times that of the next best harvest from that pond..."

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PROBLEM

Tomei Australia Pty Ltd operates a 20 hectare prawn farm 30 kilometres south of Brisbane in South East Queensland, Australia. The ponds were excavated in lowland flats on the foreshore of Moreton Bay. Tomei had identified an Acid Sulfate Soil (ASS) problem in a number of the ponds with detrimental effects on water quality (e.g. high toxic metal concentrations and low pH).

Cooked prawns from Tomei Prawn Farm.

Among other things, ASS was releasing significant quantities of sulfuric acid, iron and aluminium into the bottom of the pond, which were highly toxic to post-larvae prawns (PLPs) during their initial growing stages and was binding phosphates and other nutrients needed for the growth of natural food. As a result, overall prawn yields were extremely low in the affected ponds.

VIROTEC TOTAL SOLUTION

Virotec's ViroSoil™ Technology included the design, engineering, application and monitoring of affected prawn ponds. The ViroSoil™ Technology application, using the ViroBind™ reagent, was successful in treating the ASS problem by successfully lowering iron and aluminium concentrations and by raising and buffering soil pH.

Key benefits of the Virotec solution identified by Tomei include:

> Total treatment of ASS problems over the growing cycle of the prawn, including stable sand pH and binding of metals;
> Improvement of water quality within the ponds, as characterized by low metal concentrations, raised and buffered pH, and increased phosphates and other nutrients necessary to promote adequate food growth;
> Major improvements in pH changes naturally occurring during rainfall events as a result of residual pH buffering in the ViroBind™ reagent;
> Toxicology analyses conducted by a NATA accredited independent laboratory confirmed no increase in metals uptake in prawns;
> A single treatment prior to filling the ponds that lasted for the entire growing cycle, in contrast to repeated lime treatments;
> Direct dosing into operating ponds to rectify deteriorating water quality issues; and,
> Projected residual treatment effects occurring in subsequent seasons due to further latent benefits of the application.

As a result, the ponds experienced a PLP survival rate that was clearly higher than previously experienced in these ponds, demonstrated healthy algal blooms, and were successful in providing a stable and non-toxic food source for the PLPs.

BACKGROUND

A variety of internal and external environmental factors are meaningful to the economic and operational success of prawn farming. These include variable weather conditions, quality of pond water (DO, pH, Eh, EC, and temperature,

for example), the discharge of nutrient-rich pond effluent, which causes turbidity and eutrophication of coastal zones, site selection and enviro-aquacultural planning, and the occurrence of WSSV and MBV diseases. However, one of the most significant factors determining pond yields and the health and weight of prawns is the impact of acid sulfate soils on pond water quality.

Photograph of typical Tomei pond being aerated during growth cycle.

Acid sulfate soils (ASS) are soils and sediments containing iron sulfides. When exposed to oxygen and H2O due to any combination of exposure, drainage or disturbance, these sulfidic soils and sediments produce sulfuric acid, leading to low water pH (4.0 and below) via leaching from pond floors and/or runoff from dykes after heavy rains. Furthermore, ASS releases toxic quantities of iron (Fe), aluminium (Al) and additional heavy metals into pond water, which in turn bind phosphates and other nutrients needed for the growth of natural food.

The acidic, nutrient-depleted water, iron, and aluminium can cause significant damage to the environment and to the health of prawns, fish, birds, animals and even humans. It is generally accepted that warmer temperatures provide more favourable conditions for these bacteria to propagate, and hence the greater the potential for iron sulfides and ASS to form. ASS in tropical areas such as Queensland (where Australia's prawn farms are mostly located) typically contains higher levels of iron sulfides than ASS formed in the cooler conditions of southern states.

In a natural system, pH does not generally fluctuate greatly, with a range of 7.0-8.5 being optimal for most plants and animals, including prawns. According to Apud et al. (1983), despite prawn survival rates remaining largely unaffected at pH <7.0 (although a pH of ≤7.0 may be particularly damaging to post-larvae), prawn growth may be reduced at these levels; a pH of ≤5.0 is, however, fatal to prawns. The pH of ASS is commonly ≤4.0. Similarly, elevated levels of Fe and Al can prove deadly to the growth and survival of post-larvae, adolescent and mature prawns. Burnt lime and quicklime have been traditionally applied at 1,000-2,000kg/ha, ideally being worked into the soils and layer before filling; lime may be applied before or together with fertiliser. For longer-term pond conditioning, agricultural lime has been applied at 2,000-4,000kg/ha, although results from this practise vary significantly.

PROJECT DESCRIPTION

A treated pond at Tomei Prawn Farm.

Environmental remediation and wastewater treatment company Virotec Global Solutions Ltd and prawn farmer Tomei Australia Pty Ltd collaborated on a project to trial a solution to ASS problems in two seriously affected ponds. The ponds were constructed in a low-lying coastal area characterised by soils with a high sulfide content. The farm in southeast Queensland consists of 20 ponds, each approximately one hectare in size. Historically, sulfuric acid and heavy metals in some of the ponds migrated from marine sediments into the sand layer where prawns live and grow. These pollutants caused high post-larvae mortality and resulted in a severe reduction in prawn yields and growth. The low yielding ponds significantly affected economic returns from the venture.

Previous research at the farm (Groves, et al., 2002) had indicated that ammonia, nitrates, sulfides and iron concentrations increased at depth, with the highest levels present in the sediment, indicating to the authors a "strong sediment control on water quality". Similarly, DO fell to near fatal concentrations (<2 mg/L) for prawns at depth, Fe 2+ registered 7.10 mg/L in the sand layer, and Eh was -299 mV in the sand layer but only -53 mV on the pond surface, leading to "uninhabitable conditions at the pond bottom where prawns normally seek refuge and forage".

Tomei had in the past used lime treatment in an attempt to neutralise acidity before filling the ponds. Lime was also used on a regular basis in an attempt to remediate deteriorating water quality during the farming cycle. It was found that lime did not perform adequately. The acid neutralization effect was short-lived, and Fe and Al were still available to bind phosphates required for healthy algal blooms. Additionally, Fe and Al were found in sufficient quantities to be toxic to post-larvae prawns.

Yields from better performing ponds typically averaged around four tonnes per hectare, consistent with the climatic and environmental conditions in the region. Yields from the two ponds treated by Virotec using its ViroSoil™ Technology (Ponds 7 and 12) were trending downwards for the past six years as the ASS problem accelerated, with yields in the previous year approaching zero. Tomei were considering either decommissioning the ponds (potentially eliminating 10% of their available capacity) or undertaking radical reforms to remediate problematic ponds.

METHOD

Over a three-day period, Virotec treated the base of the ponds using ViroSoil™ Technology reagent. The single treatment method involved a two-stage application of ViroBind™ reagent, an inert mineral reagent designed to treat ASS and marine clays and to enhance nutrient retention. The total treatment area was 1.9 hectares, comprised of Pond 7 (0.7 hectares) and the more contaminated Pond 12 (1.2 hectares).

Prior to filling and stocking with Penaeus monodon post-larvae, ViroBind™ reagent was sprayed as a 5% slurry onto the bed of the ponds in those sections where the bed was too wet for direct application and applied as a dry solid toward the dryer edges of the ponds where access by tractor was more practicable. The ViroBind™ reagent layer was blended into the base of the ponds with a rotary hoe. Detailed sampling and analysis were performed before treatment to determine application rates as a function of "potential" and "actual" acidity in various areas of the ponds. Routine monitoring of ponds for pH and metals content in the sand layer and water column at depth were conducted throughout the life cycle of the ponds.

Photographs documenting the Application of ViroBind™ reagent.

RESULTS

Prawn growth rates in the ponds treated with ViroSoil™ Technology compared favourably to other ponds, with survival rates found to increase forty fold when compared to the previous year's results. The initial observations prior to stocking were of an impressive algal bloom that had not been witnessed in either of these ponds previously. Water clarity remained perfect during early prawn

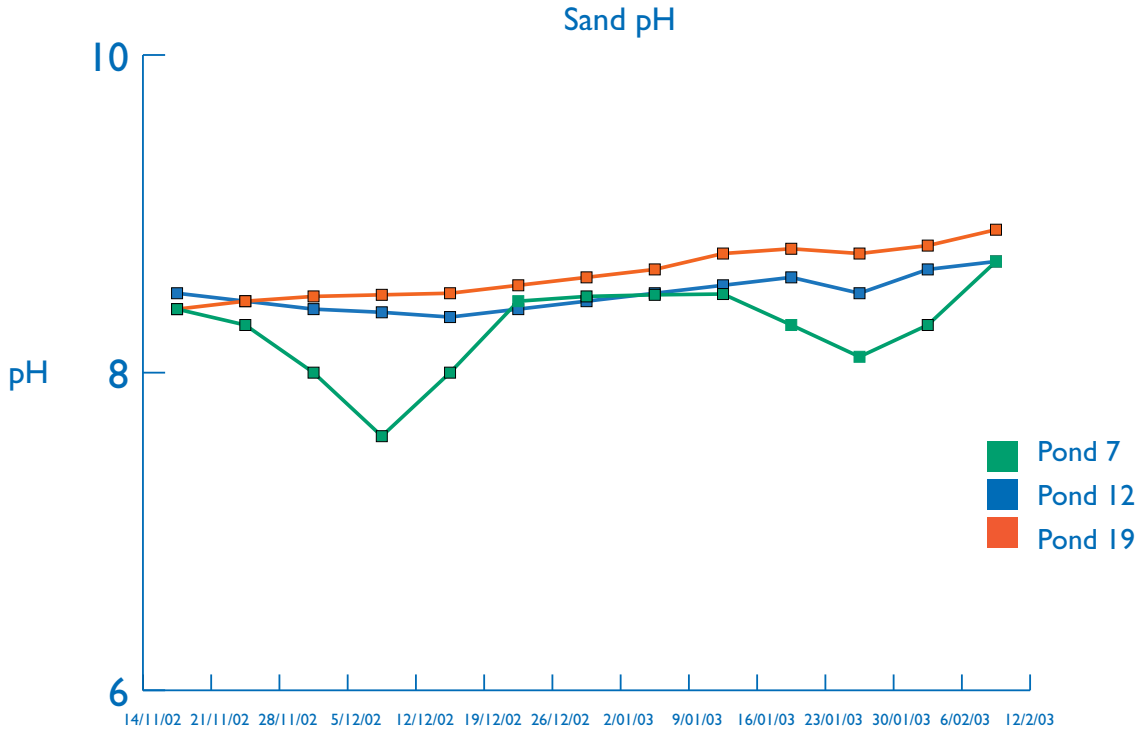
development, a factor that significantly contributed to survival rates and early growth.

The values for pH, Fe, and Al were compared to the seawater inlet and Pond 19, historically a high yielding pond, which together acted as controls. As shown in Figure 1, sand pH in Pond 19 was 8.4 in November 2002 and rose steadily to 8.9 by February 2003. Sand pH in Pond 7 was 8.5 and rose to 8.75, and in Pond 12, while experiencing two dips in pH due to rain events, began at 8.4 and rose to 8.8 during the course of the season. This phenomenon is particularly relevant to kuruma prawns (Penaeus japonicus) as they actually inhabit the sand layer.

Photographs documenting the application of ViroBind™ reagent.

The observed pH recovery after rain events suggests that, unlike lime, ViroBind™ reagent has a superior buffering capacity, allowing ponds to self-regulate and adjust for declining pond water quality throughout the seasonal cycle. Water pH ranged from 7.0-7.5 in Ponds 7 and 12, from 7.21 to 8.94 in Pond 19, and from 7.79 to 7.94 at the seawater inlet.

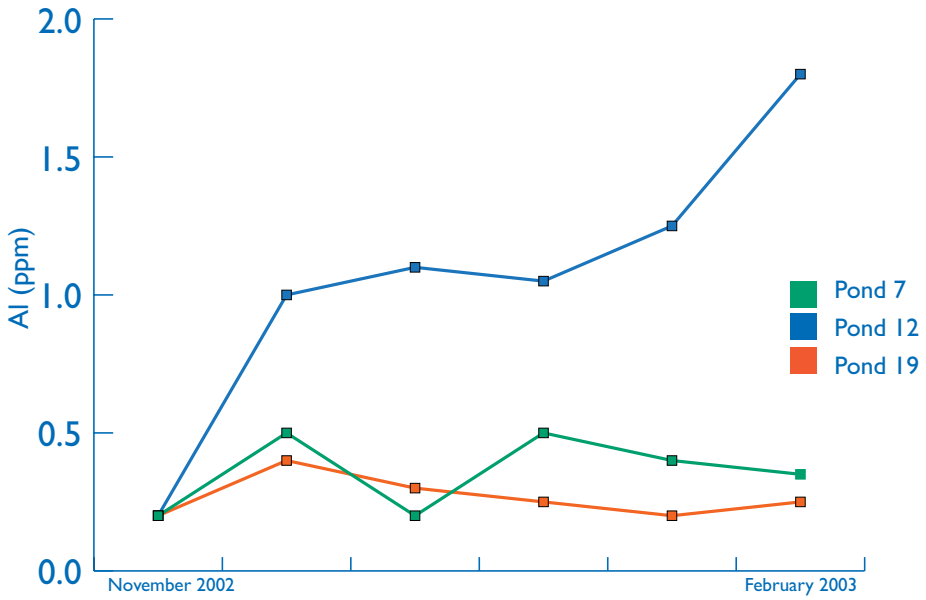
FIGURE 1: Sand pH in Ponds 7, 12 and 19 from November 2002 to February 2003



As shown in Figure 2, Al concentrations in the sand layer of Pond 19 indicate a measure of 0.35 ppm in November and remained relatively stable until February. Pond 7 Al concentrations were 0.29 ppm in November, rising marginally to 0.58 ppm, while Pond 12 concentrations were 0.38 ppm rising to 1.73 ppm. Similar trends were observed in Fe concentrations.

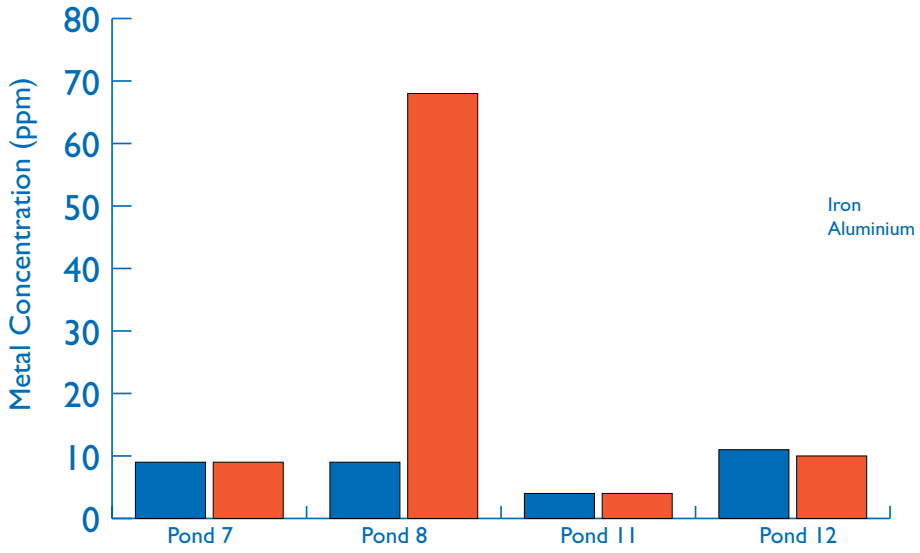
Increases in Fe and Al sand concentrations in Pond 12, while not detrimental to pond life, suggest that dosing levels could have been higher in this Pond. Concentrations for both metals in the water when measured at depth were close to or at zero parts per million in all three ponds and at the seawater inlet both during and after treatment, further suggesting the application successfully bound ASS-released metals in Ponds 7 and 12.

FIGURE 2: Sand aluminium concentrations in Ponds 7, 12 and 19 from November 2002 to February 2003



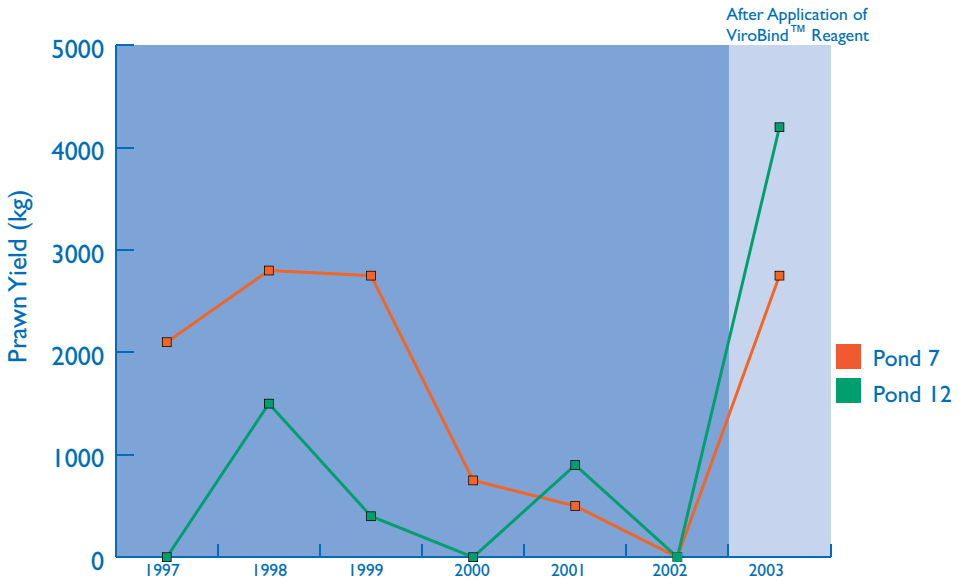
Prawn samples taken from Ponds 7 and 12, along with their adjacent Ponds 8 and 11, which acted as controls, were taken in February 2003. As shown in Figure 3, toxicology analyses performed by Australian Laboratory Services indicated there was insignificant metals uptake in prawns in the treated ponds, with results being equal to (for Al) or lower than (for Fe) those measurements taken from Ponds 8 and 11.

FIGURE 3: Metal concentrations in *Penaeus monodon* from treated Ponds 7 and 12, and in control Ponds 8 and 11



However, soil pH, sand and water metals concentrations, and toxicology are relevant only if pond yields increase. After harvest, prawn yields were found to have increased from 50kg in 2002 to 2.7 tonnes in 2003 in Pond 7, and from 30kg to 4.3 tonnes in Pond 12. Figure 4 presents the historical and post-ViroSoil™ Technology yields for Ponds 7 and 12.

FIGURE 4: Prawn yields for Ponds 7 and 12 from 1997 to 2003



CONCLUSION

ViroSoil™ Technology proved to be highly successful in countering the effects of ASS at Tomei. Sand and water pH and metal levels remained stable or within acceptable limits throughout the growing season, and metal levels in the prawns from treated ponds were comparable to prawns from elsewhere on the farm. More importantly, pond yields rose dramatically, returning ASSaffected ponds to viable levels of operational performance.

These results demonstrate the suitability ofViroSoil™ Technology in treating ASS in prawn farming.The single treatment method lasted the entire season and facilitated nutrient retention and algae growth, and self-corrected naturally occurring changes in aquatic conditions as a result of residual pH buffering in the reagent.

The results also suggest that ViroSoil™ Technology may be useful in maintaining water quality in moderately or even higher performing ponds where partial ASS may be present and when pH buffering and a one-off, pre-season treatment would be beneficial. Further work is required to determine the effect, if any, of this technology on DO and Eh levels, WSSV and MBV prevention, phosphorous and nitrogen retention, and the consequences of downstream effluent discharges.

Photographs showing stocking of pond and prawn size at harvest

As the application at Tomei Australia clearly demonstrates, the benefits of ViroSoil™ Technology are very tangible – improving prawn yield, water quality and profitability of a prawn farm operation.

TESTIMONIAL DURING TREATMENT

"The initial application to Ponds 7 & 12 of the ViroBind™ reagent product was completed on time and we were delighted with the manner in which the job was carried out. The equipment and the workmanship were first class, and we were impressed with the initial application methods and results.

Since the filling and stocking of the ponds with the Penaeus Monodon post larvae we have been closely monitoring water, algae, and prawn progress and are pleased with the level of improvement to date in the performance of the ponds.

The development of the Monodon larvae exceeds the development of the Kuruma larvae in Ponds 7 & 12 at the same period last year. The growth of algal bloom in the early stages has facilitated the development of the larvae.

The problem we were experiencing was Acid Sulphate Soils and the resultant effect on the water pH. Sulphuric acid was releasing significant quantities of iron and aluminium into the bottom of the pond, which are directly toxic to the young prawns and also bind phosphates and other nutrients needed for the growth of the natural food. The test results reported confirm the efficacy of the Virotec treatment.

The overall results so far are the best we've seen in the treatment ponds in eight years of operations and the early indications are that the yields from both ponds will at least match those of our highest yielding ponds for the same larvae type."

THORBJORN LYSTER
Operations Manager
Tomei Australia

TESTIMONIAL AFTER FINAL HARVEST

"The soil and water analytical results taken from within the prawn ponds confirmed the efficacy of the Virotec treatment. Visual inspection and toxicology analyses showed that the prawns were as healthy as any on the farm during the later stages of the crop.

Due to market factors, these ponds were amongst the last prawns to be harvested from the farm, however they appear to have survived well and were able to grow to a larger than anticipated size. It is clear at this stage that the results for at least one of the treated ponds (Pond 12) are the best we have seen for this pond in the eight years or so of its existence.

The Virotec treated pond has yielded a rate of around four times that of the next best harvest ever from that pond and in the order of 100 times better than the usual production level in this pond. For the first time since its construction this badly affected pond has produced at a commercially viable level.

At this stage it appears that the yields from both treated ponds are better than we would generally expect from these

ponds when compared with our highest yielding ponds for the same prawn species.

It is fairly clear at this stage that the Virotec treatment has had a significant, positive effect on the prawn production in our acid sulphate ponds. Some further improvements are needed for the affected ponds to produce at the levels of our best ponds, however this is not unexpected when we consider that this is the first time this method of treatment has been applied to aquaculture.

From what we have seen this year we are optimistic that with some minor adjustments to the treatment process this further improvement could be achieved."

THORBJORN LYSTER
Operations Manager
Tomei Australia

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