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The Lemna Production System

An Alternative biological system for the treatment of high saline waters from coal seam gas and coal mining operations

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Introduction

This White Paper outlines the application of the Lemna Production System to the treatment of saline water produced as a by-product of coal seam gas (CSG) and coal mining operations.

Problem Statement

Coal seam gas (CSG) producers and coal mining operators are faced with the need to remove impurities from vast amounts of water produced as a result of their respective operations.

Conventional treatment systems require significant capital and operational investment associated with installation, operation and maintenance.

In addition, these conventional systems can result in significant spin-off problems such as, but not limited to, pre-treatment issues, in particular algal blooms, and brine production as a by-product of the reverse osmosis (RO) treatment system.

CSG and coal mining companies are facing increasing compliance costs from regulatory authorities as well as the very real need to manage growing negative sentiment among community groups and landholders. Despite the very significant financial investment and employment creation by mining companies in regional communities there is a perception of poor environmental management practices across the mining industry and threats to the viability of future agricultural enterprise as a result of damage to the water table and degradation of arable land.

Previous Options

By far the mostly commonly applied solution for the treatment of water from Coal Seam Gas and coal mining operations is that of 'Reverse Osmosis'.

RO Plants is a form of desalination that utilizes microfiltration for the removal of salts and other impurities from water. A recent (2009) report by the CSIRO of 46 desalination plants across Australia shows that reverse osmosis remains the most popular engineering solution either working or being commissioned.

However, apart from cost considerations other significant technical barriers exist that need to be addressed includes:

- disposal strategies for the extracted salt compounds (brine),
- excessively pure treated water creating impediments for discharge into natural waterways; and,
- membrane fouling due to algae growth requiring pre-treatment regimes.

Other technology approaches include Ion Exchange processes. The term is used to denote the processes of purification, separation, and decontamination of aqueous and other ion-containing solutions with solid polymeric or mineralic 'ion exchangers'. While common in a range of industrial applications overseas it is less so within Australia but is likely to increase in prominence in the future.

Within the coal mining sector other technologies have been trialed each with their own inherent problems. These include water cannons and evaporation fans aimed at increasing evaporation capacity from existing water storage dams. Increasingly such approaches will decrease in acceptance as neither addresses the fundamental problems of salinity removal nor the fact that increasing community pressures require increased availability of water for re-use purposes.

It is likely that the end result with the maturing of the CSG and coal mining industries in their approaches to environment (and in particular water treatment) that a combination of technologies will need to be employed, each addressing a different combination of issues addressing the particular site in question.

One undeniable fact is the massive increase in demand for re-use of desalinated water for industrial and agriculture purposes.

> By comparison with Australia's total potable, industrial and agricultural water consumption in 2004-05 (51.5 GL/day), the amount of desalted water used in 2008 is 0.57% of that total (0.294 GL/day).
>
> This will rise to 4.3% in the year 2013.
>
> *Source: CSIRO 2009*

Community Engagement

The massive levels of extracted water from natural aquifers as a byproduct of the gas extraction process sees operators facing increasing pressures from local land holders, community groups and local industry (in particular irrigators and other agriculture producers).

Community concerns essentially encompass a number of issues the most prominent of which are:

- Decreasing availability of water from aquifers representing a significant business continuity risk for local commercial and agriculture enterprises. In turn, this places a greater emphasis on the need for real water re-use options to return extracted water back into natural water systems.
- Contaminants and other impurities as a result of the extraction process causing

harm to food chains and production systems. This also includes the propensity of the creation of algal blooms with extracted waters that render the treated water unsuitable for re-use irrespective of whether or not impurities and dissolved salts can be satisfactorily removed from the water.

- ✘ Contaminant by-products (brine) as a result of Reverse Osmosis processing.

- ✘ Uncertainty of the state of future water availability due to expansion of the industry as a whole.

Community engagement strategies have historically centered on reactive community consultation processes.

The Lemna approach creates a unique opportunity for the formation of sustainable and highly profitable community partnerships based on a non-invasive biological system that goes to the bottom line of most rural enterprises.

In particular:

- ✓ High levels of water re-use opportunity given the proven capacity for the Lemna plant to effectively and efficiently remove impurities and dissolved salts from extracted water (exceeding EPA discharge standards).

- ✓ High value commercial return from the plant by-product. Under the commercial partnership arrangements community groups can enter into royalty agreements.

- ✓ Availability of high value plant material for intensive animal farming (beef feedlots, piggeries, poultry farming etc). Extensive evaluation with Government support (Commonwealth, NSW and Victorian governments) demonstrated suitability for plant byproduct as a high-protein high-value feed supplement. Local and regionalized availability of new plant protein sources create opportunities for new industry development.

Lemna Production Systems

At the heart of any Lemna system is the Lemna plant ('Lemnaceae' also commonly known as 'duckweed'): a remarkable organism.

Under ideal conditions, a pond covered in Lemna can double its biomass every two days. The plant is also highly adaptable, flourishing worldwide under different climatic regimes. Different sub-species exist which favour a range of temperatures, light conditions, pH and the presence of toxins and heavy metals.

Although resilient, to be utilized as an effective nutrient and impurity removal system from waste waters, any Lemna crop requires effective management for the best results.

Importantly, the effectiveness of any Lemna system for water treatment requires a careful and systematic approach to balance the specific aspects related to nutrient feeding, harvesting regime, plant matter renewal, and site specific environmental conditions.

The BTWM System

The basis of the BTWM system is BTWM's two decades of R&D and installation experience in the field and has installed systems in a range of different climatic environments. This is coupled with BTWM proprietary technology (included patents) covering the integrated production and harvesting regime and equipment.

Bio-Tech Waste Management (BTWM) was formed in 1993 to develop the technology for using Lemna, a small floating aquatic plant, to remove nitrogen, phosphorus and excess mineral nutrients from municipal effluent and other forms of wastewater, including saline water generated as a result of coal mining or coal seam gas extraction.

BTWM system expertise ensures that Lemna ponds operate as closely as possible to peak

efficiency, providing the best outcomes for clients, local communities and the environment.

The BTWM system is a biological process that, when effectively managed, cleans wastewater to a standard that allows the water to be reused for irrigation, industrial use or released into natural waterways.

One of the benefits of the BTWM system is that it also effectively eliminates algae – creating greater opportunities for the reuse of wastewater. Control of algae growth means that wastewater can be commercially utilised for a variety of purposes, including the development of existing and new industries, especially where drip irrigation is used.

Control of algae also assists in the smoother functioning of RO treatment systems.

While the BTWM system is currently in place within a number of municipal and waste water treatment sites (such as that of NT Power & Water) an industry specific coal mine operation evaluation trial has now been committed with the support of BHP-Mitsubishi Alliance (BMA) in central Queensland. Upon conclusion of this evaluation it is anticipated that a multi-site installation strategy will be considered.

The project design and planning for this phase of the project is being conducted as a partnership with Queensland University of Technology (QUT).

Economic Benefits

The value proposition for a BTWM goes well beyond that of being a simple biological system for the treatment of waste water. It is its inherent value as an agriculture commodity in its own right makes a Lemna Crop a source of significant revenue sources through its commercialisation as a value-add feed product. It is for this reason that its real value is as a high-value plant crop with protein value equivalent to soy-bean meal.

Value as animal feed

Lemna harvested from wastewater ponds can be used as an inexpensive, high-protein feed supplement. At 30-40%, the protein content of duckweed is equal to that of dried soybean meal. Chickens, ducks, sheep, pigs, cattle and rabbits will all thrive on duckweed.

Moreover, duckweed is far more productive than other feed crops on a per hectare basis. In terms of protein yields per hectare, duckweed is at least 10 times more productive than soya beans.

Studies carried out by University of New England (Armidale, NSW) and the Department of Primary Industry (DPI) Queensland have shown that Lemna has enormous value as a vitamin-rich feed supplement.

Lemna has particular value as a poultry-feed. The plant contains high concentrations of calcium equal to 10-25 g/kg dry matter, ideal for stimulating healthy egg production. In addition, harvested duckweed has large amounts of xanthophylls and carotene, which impart a rich yellow/orange colour to egg yolks.

Value in aquaculture

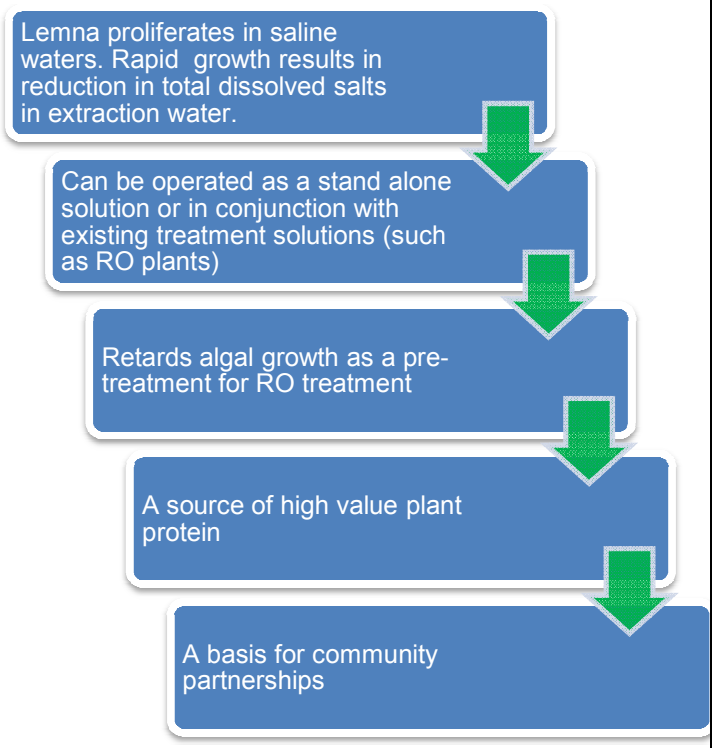
As wild fish stocks dwindle, fish-farming has grown. However, conventional aquaculture can actually increase the pressure on marine ecosystems, because it takes 4 kg of wild fish to produce1 kg of fish-meal. Fish-farming using duckweed offers an alternative.

Duckweed provides a complete nutritional package for a range of commercial fish species. It can also be used to as supplement to other feeds. Duckweed has also been used as a feed for crayfish and fresh water prawns, although this practice is in its infancy.

Research into its application as a feed source for animals and in aquaculture has been supported through extensive trial and evaluation by the Commonwealth, Victorian and Queensland State Governments.

Conclusion

The BTWM System is an integrated holistic approach to water treatment and the production and commercialisation of a high value plant protein source. For this reason the BTWM can become the basis (either in whole or in part) for addressing a major CSG and Coal mining sector industry problem as well as the foundation of the creation of sustainable and commercially valuable community partnerships between industry operators and local community stakeholder groups.



Reports and Research

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