Slade, M. Pressure Sewer Services Australia. Verbal information recorded at the Lawrence Close out workshop on the 23rd February 2010.

BARLEY STRAW: A NATURAL ALGAE INHIBITOR

Paper Presented by:

John Holmes

Author:

John Holmes, *Operator Woolgoolga Water Reclamation Plant,*

Coffs Harbour Water

4th Annual WIOA NSW Water Industry Engineers & Operators Conference
St Stanislaus' College, Bathurst
20 to 22 April, 2010

BARLEY STRAW: A NATURAL ALGAE INHIBITOR

John Holmes, *Operator Woolgoolga Water Reclamation Plant,* Coffs Harbour Water

ABSTRACT

Over the warmest summer months, algae grows in the balance tank at Woolgoolga WRP, creating a multitude of problems, including pH, TSS, increased sludge production, increased CO_2 usage to aid pH correction, fouling of reuse filters, resulting in increased backwashing frequency and power usage. Barley straw has been previously used to control algae in sewage tertiary ponds in Central Queensland. As the barley straw breaks down, it releases an enzyme, which in the presence of dissolved oxygen can control certain algae. Limited trials were conducted at Woolgoolga during the summer of 2008/09. In November 2009, following the success of these trials, ten bales of barley straw were placed in mesh bags and secured in the balance tank, costing a total of $200.

ABOUT THE PLANT

Woolgoolga WRP was upgraded and modified in 2003. The plant design consist of line step screen and air lift grit sequence, followed by two sequence batch reactor with effluent discharging to a catch pond with two banks of Aquadisk cloth filter, filtering the effluent before discharge to reuse water systems and/or ocean outfall.

Sludge from the filters backwash and filtering is pumped to a duty sludge lagoon where it under goes *forearth* processing before flowing to a storage lagoon and then final removal on four drying beds. The typical effluent nutrients released to the catch pond are: shown in Table 1.

Table 1: ***Typical nutrient result of catch pond effluent***

Ammonia	Nitrate	Phosphate	Turbidity	pH
0.10 mg/L	3.2 mg/L	0.31 mg/L	0.5 NTU	7.02

1.0 INTRODUCTION

Algae caused a number of problems in the Woolgoolga WRP effluent. It impeded filter performance, increased sludge volume and handling, increased pH of the final effluent to name a few and therefore needed to be controlled in the catchment pond.

There have been numerous attempts at controlling the algae with varying cost - one being a vacuum system at a cost of $35,000, plus daily maintenance for one operator at normal operational cost - approximately $50 000 dollars per year ongoing.

The cost of the barley straw and other material required to contain the straw was $200 dollars plus the cost of two operators to install the system. Ongoing costs only involved daily monitoring as walking past on other daily duties. This is a substantial saving.

There has been some evidence since 1970 that barley straw can be used to control blooms of algae in fresh water systems. There are many published accounts reporting consistent suspension for years in a row of algae blooms (Centre for Ecology and Hydrology, 2004 Information Sheet Control of Algae with Barley Straw; Control of Algae using Barley Straw, Dr Jonathan Newman, Pip Barrett).

Where previously such blooms were a regular occurrence within dams and waterways, the use of barley straw bales has been implemented with no apparent undesirable side effects.

Thus it was not much of a leap too apply this technology to a WRP catch pond and possibly ameliorate the effluent quality. Barley straw offers a cheap, environmentally acceptable and sustainable method of algal control.

Regardless of simplicity of the idea, anecdotal research has shown that there are several basic rules that must be followed to ensure that the straw works successfully as a microbial biological control method. Centre for Ecology and Hydrology, 2004 Information Sheet Control of Algae with Barley Straw; Control of Algae using Barley Straw, Dr Jonathan Newman, Pip Barrett.

This paper will describe one possible mechanism on how straw bales work, followed by the method and how the barley straw was applied at the WRP and the results from the application of straw to the catchment pond.

The algae at Wollgoolga WRP are Scenedesmus, chlorella, palmella, pediastrum, tabellaria, diatoma, closterium.

2.0 HOW BARLEY STRAW WORKS

In order to use barley straw effectively, it is necessary to understand something of how the process works.

- When barley straw is put into water, it starts to decompose and during this process chemicals are released which inhibit the growth of algae. As mention, the algae at Wollgoolga WRP are Scenedesmus, chlorella, palmella, pediastrum, tabellaria, diatoma, closterium, with the main species being diatoms identified by Coffs Harbour City Council Laboratory.
- Rotting is a microbial process and is temperature dependent, which causes it to being faster in summer than winter.
- It may take six to eight weeks for the straw to become active at low water temperature, but approximately three week when the water temperature is above 20c. Therefore during activation period algae will continue to grow.
- Once the straw is activated, the applied dose of straw remains active for approximately 4 months.

3.0 THE MECHANISM

The exact mechanism by which straw controls algae has not been fully investigated, but it is general accepted that the process may occur as such: Centre for Ecology and Hydrology, 2004 Dr Jonathan Newman., Barrett, P. 2004, Geiger, S., Henry. E., Hayes. P, K Haggard, K, 2005

When straw is first placed into water, the soluble components of the straw are washed out. These compounds have not been identified, but they are likely to be a mixture of carbohydrates and hemicellulose. Bacteria are the most dominant microorganisms at this stage growing on the carbohydrate reserves in the straw. Centre for Ecology and Hydrology, 2004.

After about two weeks the dominant micro-flora changes to fungi. This is when decomposition of the lignin and other cell wall components start to occur by lignase enzymes produced by the fungi. (Centre for Ecology and Hydrology, 2004).

- When straw rots, the cell wall components decompose at different rates. Lignin is very persistent and is likely to remain and be released into the water as other components decay (Centre for Ecology and Hydrology, 2004).
- Decomposition of the lignin leads to the production of a form of soluble lignin and other decomposition products. These decomposition products are likely to be transformed by bacterial and fugal enzyme activity being released into the surrounding water (Centre for Ecology and Hydrology, 2004).
- This mixture of compounds is transformed into fulvic and humic acids. These humic substances are more easily referred to as Dissolved Organic Carbon (DOC). DOC is a natural component of many fresh water ecosystems. When light shines onto the water that contains humic substance, in the presence of oxygen and sunlight hydrogen peroxide is eventually formed.
- High molecular weight DOC absorbs sunlight energy and passes this energy to dissolved oxygen molecule. The dissolved oxygen becomes unstable and decomposes into two singlet oxygen radicals. These are very short lived, but are extremely reactive molecules. The singlet oxygen radicals form superoxide radicals, and these radicals form hydrogen peroxide, which are slightly more stable and may, persists for up to 2 day (Centre for Ecology and Hydrology, 2004).
- Concentrations of 2ppm peroxide have been demonstrated to inhibit the growth of algae. Experiments have shown that sustained low concentrations of hydrogen peroxide can have a very similar effect on algae to that of straw.
- Straws anti-algae effect is only productive if the straw is rotting in well aerated (aerobic) conditions. If the bales or netting that contains the straw are excessively compact, or if there insufficient water movement anaerobic conditions will develop in the straw and the only part of the bales that will be effective is the outside surface layer of the bales where there is sufficient oxygen to meet the required condition.

Sediments will react with the products released from the rotting straw, thus in conditions where sediments occur the effective dose rate of amount of bales must be increased to overcome this demand. (Butler, B., Terlizzi, D., Ferrier, D. 2005) The daily monitoring by the operators in their general duties, will allow for the adjustment of number of bales to be used and their use by rate.

From the research it appears that barley straw is the most effective and long acting, better then wheat or other straws. (Dr Jonathan Newman., Barrett, P. 2004) Once the straw becomes active the time will varies depending on the type of algae, temperature and when the straw is added to the water system.

- The dose rate at Woolgoolga is approximately 50 grams per square metre, but research has shown the dose rate may fluctuate between 20 to 50 grams per square metre and in most cases a initial higher dose rate is used followed by a subsequent lowering once the algae is under control.

From the research it appears that there is no reported effect on high plant species, invertebrate animals or fish. (Dr Jonathan Newman., Barrett, P. 2004).

- Most effluent discharged from Woolgoolga WRP is used for irrigation purposes

to support banana and blue berry industry.

It is found that the most important quantity in the straw application calculation is the surface area of the water body to be treated, as this is the region where algae growth takes place.

4.0 METHOD

The method of use at Woolgoolga WRP to apply the straw was to place the straw in a two metre section of nylon bird netting, wrapping the netting twice around the straw and sowing all end together with cable ties, thus preventing any straw escape. A weight and rope are then attached to the bail to secure it in the required location, as the bails are inclined to float.

It was established that the use of 20 metre by 5 metre bundle of net was the simplest technique to fabricate the desired bales. Just by cutting the net into two metre lengths along the 20 metre length allowed two raps of the bail with the 5 metre width.

The area to be treated was approximately 80m by 40m, which equals 3200 meters square requiring 160kg of straw.

- The catch pond receives approximate 2.5 ML a day (ADWF), with power tariff restricting (restrictions, inhibiting ability) to pump the effluent.
- The bales where scattered around the catch pond, with a partition being constructed to aid the flow in the desired direction and to avert any short-circuiting.

The addition of the straw to the catch pond this year was two months late consequently algae was well established in the catch pond. It took some 30 days before obvious reduction to the algae population was noticed.

The algae was measured at the end of pumping cycles when the catch pond depth was 300 mm on the south side of the dividing wall. This is were algae accumulated and is at its greatest depth.

5.0 RESULTS

Table 2: ***Results of Monitoring***

Week	*Algae average depth in catch pond*	*Average Turbidity from filter inlet*
1	120 mm	80 NTU
2	115 mm	85 NTU
3	105 mm	60 NTU
4	80 mm	30 NTU
5	60 mm	25 NTU
6	35 mm	23 NTU
7	20 mm	20 NTU
8	5 mm	21 NTU

The depth of the algae in the catch pond is now on average less than 1 to 2 mm

- The average turbidity at the filter inlet is now 12 to 15 NTU

- The backwash cycles before the application of straw were initiating at 10-minute intervals, now they are only initiating once during normal pump cycles or every two hours during constant operation.
- The CO_2 usage has decreased form 80 kg a week to approximately 70 kg a fortnight.
- The pH decreased from 10 plus to a more acceptable 8.4 or less, where the CO_2 corrected to 7.6.

The reapplication of straw ought to take place once the straw has decomposed to approximately 20 to 30 percent of its initial volume or when an increased in algae growth is noted. The new straw should be added as a supplement whilst leaving the old straw in position pending the newly added straw activation. The old straw is removed and applied to gardens within the treatment plant grounds.

6.0 CONCLUSION

This simple and inexpensive system greatly reduced algae and algal blooms during the warmest months resulting in improvements in effluent quality.

The enzyme released by microbial decomposing barley straw in the presence of oxygenated water and sunlight was successfully used to control algal growth in the balance tank at Woolgoolga WRP;

This resolved the operational and final effluent quality issues

- Of CO_2 usage,
- pH balancing,
- The increase in NTU‘s from algae in effluent being treated by filters
- Increased sludge production, from fouling of reuse filters
- Increased in manual cleaning of the cloth filters system
- Increased in power usage

Thus resulting in saving in overall cost saving to the operational budget, with no effects to the end irrigating user.

The netting and materials to contain the straw was cheap to buy and easy to fabricate.
This basic, economical biological control system may perhaps be beneficial in controlling algal growth in other sewage effluent storage ponds, with consequences of enhancement to water/effluent quality with a resulting benefit, of cost saving to the budget.

As this is still an ongoing trial and from the many reports read and ongoing research there still much debate of the endorsement of barley straw for effective algae control. In saying that, the operators to date has found this an effective means to control algae in Woolgoolga WRP for two years, and because of the low capital cost encourage other operators in other council areas to trial the method.

As this a natural control method that is economical and environmentally sustainable, some patience and restraint should be shown before dismissing it as a failure. If it does not start working within a two to three weeks time frame.

The data that I have presented in this paper from Woolgoolga WRP in our trial has added to the growing knowledge base for the use of barley straw as a method of containing algal growth in waterways and catchment tanks.

When we approached our Process Engineer with data and observational experience in using this barley straw method for algal containment at Woolgoolga WRP, he was at first sceptical, our Works Coordinator Ian Wilson approved the initial trial. Following the results of the initial trial, and the low implementation costs, the Manager Water Treatment authorised the current trial.

Now after two years of data collection and trial, plus the added benefit of cost savings and operational benefits etc, this method has been accepted as part of the Woolgoolga WRP operations. With two years experience, the Manager Water Treatment has requested the barley straw be installed again next year, prior to the warm weather.

7.0 REFERENCES

Barrett, P. R. F., J. C. Curnow, and J.W.Litterjojn, 1996
The Control of Diatom and Cyanobacterial Blooms in Reservoir using Barley Straw.

Geiger, S., Henry. E., Hayes. P, K Haggard, K, 2005
Barley Straw – Algae Control Literature Analysis.

Geiger, S., Henry. E., Hayes. P, K Haggard, K, 2005
Barley Straw for Algae Control – Phase 11
Agricultural Research Foundation, Final Report.

Hill, D., Stoops, R.
Barley Straw Algae Control Research
WGI Online Journal: **www.watergardenersinternational.org/journal/1-1og/algae-control.html**

Butler, B., Terlizzi, D., Ferrier, D. 2005
Barley Straw: A Potential Method of Algae Control in Ponds.

Dr Jonathan Newman., Barrett, P. 2004
Information Sheet Control of Algae with Barley Straw; Control of Algae using Barley Straw.

Centre for Ecology and Hydrology, 2004
Information Sheet Control of Algae with Barley Straw
www.capm.org.uk