THE EFFECT OF BARLEY STRAW ON ALGAE

Literature Review

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EFFECT OF BARLEY STRAW ON ALGAE

Algae are photosynthetic aquatic organisms that are found in both freshwater and seawater. Algae are distinct from plants in several ways. They do not have proper stems, leaves, roots or a vascular system to circulate water and nutrients. They can be largely categorised into microscopic algae (a single cell) and macroscopic algae (multicellular, filamentous and/or colonial) [1] [2]. The susceptibility of different algal species to barley straw is outlined in Annexure A.

IMPACTS OF ALGAE

Environmental	• Depletes dissolved oxygen content in the water deteriorating conditions for aquatic life [3] • Environmental problems as a result of excessive algal blooms [4]
Economic	• Filamentous algae clog pumps, screens and emitters in agricultural irrigation systems [5] • Decline in fish productivity [6] • Toxic contamination of shellfish [6]
Social	• Unpleasant tastes reduce the water intake of livestock and can render water from reservoirs unfit for human consumption [4] • Mat forming species hinder recreational fishing, swimming and other activities [4, 5] • Considered unsightly by the general public [4] • Some algae, if ingested can cause illness or skin irritations [3]

BARLEY STRAW

Use of barley straw to suppress algae growth dates back to the Middle Ages, when countries started to experience cyanobacteria outbreaks in drinking water supplies. People started drinking liquor made from barley rotted in water because the alcohol was sufficient to kill pathogenic bacteria [7]. In 1980, a farmer noticed that an accidental addition of rotting straw reduced algae growth the following year [4]. Since then, barley straw's ability to control algae has been well-studied and documented. Decomposing barley straw in well aerated water releases compounds that inhibit algal growth. It has been shown that barley straw is active against a range of algae including unicellular and filamentous forms [8].

USE OF BARLEY STRAW FOR THE MANAGEMENT OF ALGAE IN AUSTRALIA

- Barley straw has been successfully used in Central Queensland to control algae in sewage tertiary ponds [9]
- Woolgoolga Water Reclamation Park in Coffs Harbour NSW has accepted the placement of barley straw mesh bags as a beneficial method of containing algal growth in waterways and catchment tanks [9]
- Barley straw is recommended by the Western Australia Department of Primary Industries and Regional Development for the management of blue-green algae on farms [10] [11].
- In Victoria, barley straw is listed as a treatment option for blue-green algae in farm dams and farm storages by Agriculture Victoria [12]
- The Environmental Protection Authority (EPA), Department for Environment and Water, and Primary Industries and Regions South Australia SA use barley straw as a management strategy for blue green algae [13].

USE OF BARLEY STRAW INTERNATIONALLY

- Barley straw is used in many reservoirs and dams in the United Kingdom with positive results for algae control [14].
- The Aquatic Weeds Research Unit (AWRU) at Long Ashton Research Station has records of reports detailing the management of algae using barley straw in Canada, Ireland, South Africa, Sweden and the USA [15].

BENEFITS OF USING BARLEY STRAW

- ✓ Cheap [9]
- ✓ Natural product [16]
- ✓ Environmentally acceptable and sustainable method of algal control [9]
- ✓ Addition of straw to pond can result in the development of large populations of fish food organisms such as zooplankton and other macro invertebrates [16]
- ✓ Toxicity of rotting barley straw is selective for algae so other plant forms in or near the treated water are not harmed [16]
- ✓ Blue green algae which are the most noxious group of algae are sensitive to chemicals released from rotting straw [16]
- ✓ Long lasting. A single application of straw may last several (4-6) months [17]
- ✓ Require low labour inputs [16]

HOW IT WORKS

When barley straw is put into contaminated water, it has two effects:

Nutrient stripping	• The high carbon-to-nitrogen ratio of barley straw means that when it breaks down it uses available nitrogen and phosphorus in the water. This reduces conditions favourable to algae growth [10]
Release of compounds	• Decomposing barley straw release a cocktail of toxins which are harmful to the growth of algae [9]

FACTORS THAT AFFECT PERFORMANCE

Weather	• High temperature water and turbulence induced by the wind and wave action helps the decomposition process [18] • Rotting is a microbial process and is temperature dependent; faster in summer than winter [9]. • It may take six to eight weeks for the straw to become active at low water temperature, but approximately three weeks when the water temperature is above 20^{o}C [5].
Aeration	• 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. The only the outer surface of the bales that will be effective [9].
Turbidity	• Waters that are highly turbid with suspended mud absorb and inactivate chemicals released from decomposing barley straw. Therefore it is necessary to use at least double the recommended quantity of straw [5].
Type and size of algal growth	• Small, unicellular species disappear within 6-8 weeks [19] • Larger filamentous algae can survive for long periods and may not be controlled adequately if the straw is added too late in the growing season when the algal growth is dense [19]

MANAGEMENT PERIOD

Best period to add the barley straw is early spring to early summer, before water conditions favour algae growth [5]. In early summer, warmer waters make the barley straw more effective. When the surface layer of water is greater than 21°C, adding barley straw to an existing bloom may be effective within 2 weeks [9].

BARLEY STRAW VS BARLEY STRAW EXTRACT

Use of both physical straw and liquid barley straw extract has shown to inhibit the growth of algae. Research has shown that straw inhibits the growth by 20-40% on average with greatest inhibition (approx. 70%) occurring in straw allowed to rot for six months [20]. Liquid extraction concentrations as low as 0.005% have shown inhibition of algae by 90% [21].

REFERENCES

[1] B. E. Publishing and S. Hollar, *A Closer Look at Bacteria, Algae, and Protozoa*. Britannica Educational Publishing, 2011.

[2] A. Vidyasagar. (2016). *What Are Algae*. Available: https://www.livescience.com/54979-what-are-algae.html

[3] Water NSW. (2020). *Dangers and Problems of Algae*. Available: https://www.waternsw.com.au/water-quality/algae/dangers-and-problems

[4] M. D. Ferrier, B. R. Butler, Sr., D. E. Terlizzi, and R. V. Lacouture, "The effects of barley straw (Hordeum vulgare) on the growth of freshwater algae," *Bioresour Technol,* vol. 96, no. 16, pp. 1788-95, Nov 2005.

[5] B. Prf and J. Newman, *Centre for Aquatic Plant Management INFORMATION SHEET 1: CONTROL OF ALGAE WITH BARLEY STRAW*. 2012.

[6] J. Robinson and T. Cully. *Economic consequences of algal blooms*. Available: https://ozcoasts.org.au/indicators/coastal-issues/econ_cons_algal_blooms/#identifier_3_2882

[7] G. Wefer, W. H. Berger, K. E. Behre, and E. Jansen, *Climate Development and History of the North Atlantic Realm*. Springer Berlin Heidelberg, 2013.

[8] J. M. Pillinger, J. A. Cooper, and I. Ridge, "Role Of Phenolic Compounds In The Antialgal Activity of Barley Straw," *Journal of Chemical Ecology,* vol. 20, no. 7, 1994.

[9] J. Holmes, "Barley Straw: A Natural Algae Inhibitor," in *4th Annual WIOA NSW Water Industry Engineers & Operators Conference*, Bathurst, 2010, pp. 33-39: Slade, M. Pressure Sewer Services Australia, 2020.

[10] A. Erickson. (2020). *Managing blue-green algae on farms in Western Australia*. Available: https://www.agric.wa.gov.au/livestock-biosecurity/managing-blue-green-algae-farms-western-australia

[11] T. Westrup. (2020). *Contaminated farm dams* Available: https://www.agric.wa.gov.au/water-management/contaminated-farm-dams

[12] Agriculture Victoria. (2020). *Managing blue-green algae in farm water supplies* Available: https://agriculture.vic.gov.au/farm-management/water/blue-green-algae-in-water/managing-bluegreen-algae-in-farm-water-supplies

[13] EPA, Department for Environment and Water, and Primary Industries and Regions SA, "Post-bushfire water quality in farm dams and creeks," ed, 2020.

[14] Water Quality Research Australia, "Management and control in source waters," in *International Guidance Manual for the Management of Toxic Cyanobacteria* G. Newcombe, Ed. United Kingdom: Global Water Research Coalition 2009.

[15] J. M. Caffrey, P. R. F. Barrett, K. J. Murphy, and P. M. Wade, *Management and Ecology of Freshwater Plants: Proceedings of the 9th International Symposium on Aquatic Weeds, European Weed Research Society*. Dordrecht: Dordrecht: Springer Netherlands, 1996.

[16] C. E. Boyd and C. S. Tucker, *Pond Aquaculture Water Quality Management*. Springer US, 2012.

[17] J. Caffrey, P. R. F. Barrett, K. J. Murphy, and P. M. Wade, *Management and Ecology of Freshwater Plants: Proceedings of the 9th International Symposium on Aquatic Weeds, European Weed Research Society*. Springer Netherlands, 2012.

[18] J. Caffrey, P. R. F. Barrett, M. T. Ferreira, I. S. Moreira, K. J. Murphy, and P. M. Wade, *Biology, Ecology and Management of Aquatic Plants: Proceedings of the 10th International Symposium on Aquatic Weeds, European Weed Research Society*. Springer Netherlands, 2013.

[19] L. Hutchinson, *Ecological Aquaculture: A Sustainable Solution*. Permanent Publications, 2005.

[20] M. T. Gibson, I. M. Welch, P. R. F. Barrett, and I. Ridge, "Barley straw as an inhibitor of algal growth II: laboratory studies," *Journal of applied phycology,* vol. 2, no. 3, pp. 241-248, 1990.

[21] P. R. Shewry and S. E. Ullrich, *Barley : chemistry and technology*, Second edition. ed. St. Paul, Minnesota : American Association of Cereal Chemists, 2014.