Using turbidity tolerant water plants in the rehabilitation of turbid farm dams

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Frontispiece

Son: I'm sick of the Internet. I want a yabby net.

Father: Well you can't have one. It would corrupt you. You would end up staring into some strange dark pond all day: some pond full of reeds and mud.........and mysterious life forms.

Then you would stare at the reflection on the water and see the sky, the clouds and the birds all quite differently.

You would throw a stone into the pond causing the reflection to ripple and distort. And gazing at it you would fall into a trance of wonderment and delight and never fit into normal life again.

Sorry - no yabby net!

Michael Leunig

Declaration

To the best of my knowledge and belief, this thesis contains no material previously submitted for a degree or any other award, in any university by any person, or any material previously published or written by any other person, except where due reference is made in the text. I consent to the thesis being made available for copying and loan if accepted for the award of the degree provided due acknowledgement is given.

[redacted]

Annabel Douglas-Hill

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Abstract

The colonization of some Australian wetlands by submerged water plants appears to be restricted by high water turbidity, which reduces underwater light and this turbidity appears to be a permanent state in many wetlands. A relationship between the lack of submerged water plant cover and high phytoplankton concentrations, particularly of blue-green algae, has been observed in turbid farm dams. Water plants are known to reduce algal blooms, clarify the water and improve water quality, but the processes of submerged water plant establishment are not fully understood.

This research project set out to investigate the influence of turbidity on submerged water plant germination and establishment and to find turbidity tolerant species that could be used to rehabilitate farm dams. Two seed banks, one from a natural but temporary wetland, and one from a permanent man-made wetland, were examined for water plant germination and establishment under four turbidity and three depth treatments in artificial ponds. The underwater Photosynthetically Active Radiation (PAR) was found to be reduced to below that needed for photosynthesis in about 30 cm of water with a mean turbidity of 135 nephelometric turbidity units (NTU). Germination from the two wetland seed banks showed no reduction in species richness with increasing turbidity under constant depth, but long periods of turbidity would probably affect the composition of the water plant community. Four submerged charophyte species (plant-like algae) were stimulated by an increase in turbidity to significantly increase their numbers, biomass and length while angiosperm species were suppressed by the permanent flooding regime. Charophytes (also known as stoneworts) from the seed bank of the temporary wetland developed the highest biomass, whereas in the seed bank from the permanent wetland, the submerged angiosperm, *Vallisneria gigantea,* had the greater biomass. The species that dominated germination from the seed bank in the pond and glasshouse trials could be predicted from observing the species in the wetland from which the seed bank was sourced and the water regime. This study suggests that charophytes may be adapted to turbid conditions. By using the functional classification method for wetland plants of Brock and Casanova (1997) it was shown that most 'fluctuation tolerators' (emergents and low growing species) germinated and established in the shallows where there was sufficient PAR. 'Fluctuation responders' (plastic and floating plants) however, were able to grow from a greater depth and emerge above the turbid water to photosynthesize and reproduce. Two submerged angiosperms, *Vallisneria gigantea* and *Potamogeton ochreatus,* were found to be tolerant of turbidity. Many farm dams and wetlands have turbidities of less than 135 NTU and the results of this experiment show that light is not the main factor limiting submerged plant establishment.

Since some water plants could establish under turbid conditions, a biological and chemical manipulation experiment was undertaken over 8 months in the Northern Tablelands of New South Wales, Australia. It aimed to establish water plants in farm dams and 'switch' them from a turbid state to a clear, water plant dominated state and test the hypothesis that clearing was not necessary for submerged plant establishment. Twelve turbid dams up to 3 m deep with no submerged or floating plants and without fish were chosen. Dams were fenced and domestic stock excluded or allowed only limited access.

Glasshouse trials were carried out on farm dam sediments both before and after the treatments, which showed that most farm dams had poor quality seed banks with few seedlings emerging before the treatments. Even though more species of water plants germinated in the glasshouse after the treatments, this increase also occurred in the control groups, which suggested a seasonal cause. Protection from grazing animals in the glasshouse also contributed to more species being observed there than in the field.

Laboratory tests were performed to determine the best chemical with which to flocculate suspended soil and algae. It was found that when lime flocculated clay and green algae in field and laboratory situations, it did not flocculate cyanobacteria (blue-green algae), as aluminium sulphate did. Aluminium sulphate was known to be toxic to aquatic animals and water plants so it was decided to use lime as the flocculating agent. Introduced seed bank collected from the temporary wetland (used in the previous pond trial) was used as the biological treatment as it contained turbidity tolerant charophytes and angiosperms. This seed bank was chosen because it did not have seeds of *Vallisneria* or *Typha*, species that under certain circumstances may dominate the vegetation of farm dams.

In early spring when green algae started to increase in abundance experimental treatments were applied to the farm dams. The treatments were either addition of lime (chemical treatment) or addition of seed bank (biological treatment), a combination of both lime and seed bank (chemical and biological treatments), and a control in which no treatments were applied (control). Three dams were used as controls. Water quality variables and submerged plant establishment was monitored for four months before and four months after treatment. The increase in the clarity of the water (as secchi disc depth) was measured. By introducing seed bank material to the dam sediments it was anticipated that submerged water plants would germinate and establish with increased light. Results showed that 4 months after treatment there was a significant difference in secchi disc depth in the lime and seed bank–lime treated dams but not in the control and seed bank treated dams. Chlorophyll$_{-a}$ concentrations were reduced in all treatments but increased in the control group. The addition of seed bank did not increase submerged plant establishment in 6-8 weeks in the field as occurred in the artificial ponds. Grazing by ducks and aquatic animals was detrimental to water plants and although water clarity improved in some dams there was no corresponding increase in submerged water plant germination. Lime treatment did not sustain water clarity in the long-term and high turbidity could indicate upstream erosion even where catchments are well-protected, not just wind and wave resuspension of sediments. Appropriate methods for protection from grazing birds and animals needs to be established as well as increased soil erosion control upstream, all which affected submerged plant establishment.

Where seed bank was used, colonization of the dam edges by emergent species was visible where slope was low but was not investigated. In contrast, submerged species were not successful in establishment. Long dry periods and the steep slopes of many dams led to large fluctuations in depth and did not support the establishment of any but the more hardy *Cyperus*, *Persicaria*, *Portulaca* and *Chenopodium* species and the naturalized couch and paspalum grasses.

Twenty months after treatment the secchi disc depth in the seed bank-lime and the seed bank treatment groups were higher than in the lime and control treatment groups. Unfortunately the averages were affected by stock disturbance to two dams of the previous two groups. In only one seed bank treated dam was there any large increase in submerged water plant germination. This dam had a 100% cover of *Nitella sonderi* to 0.54 m with a drop in turbidity from 57.8 NTU (av.) before treatment to 15.4 NTU; corresponding to an increase of secchi depth of greater than 1 metre. Soluble reactive and total phosphates were reduced in this dam by 50%/ 40% and 94%/ 77% four months and 20 months respectively after treatment. The establishment of submerged water plants in one dam out of six treated with seed bank may have occurred by chance alone, so it is uncertain if the addition of seed banks containing oospores of turbidity tolerant charophyte species was the mechanism which produced the 'switch'.

The long-term results of this project have shown that water plants can establish in turbid situations and at shallow depths so it is not necessary to clear the water to enable them to germinate. Farm dams can indicate the state of catchments and highly turbid dams indicate upstream erosion is occurring and control of this erosion must be a priority before water clarity can start to improve. Landcare groups can monitor the clarity of farm dams after rainfall events using secchi discs that would help them manage upstream soil erosion turbidity. Algal blooms may be natural and seasonal occurrences but when the blooms are excessive they can indicate a build up of nutrients in a water body. Lime can be used to manage these algal blooms in dams and postpone succession by blue-green algae, but this is a treatment for which long-term outcomes are unknown. There was an increase in water clarity in one of the seed bank treated dams in which charophytes established but this is in no way conclusive as it happened outside the time frame of the project. Further research should be done on establishment of water plants, as blue-green algae remain a serious problem in Australian farm dams. Charophytes are small and low growing and provide habitat for algae consuming zooplankton and these three characteristics make them ideal for use in farm dams.

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