PhD Thesis

Using the Submergent *Triglochin huegelii* for

Domestic Greywater Treatment

by

Ross Mars


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Abstract

In recent years, there has been increased interest in alternative and innovative technologies which are used in the treatment of wastewaters, with the aim of developing efficient systems which are low-cost and low-maintenance. However, greywater reuse from domestic houses appears to have received very little attention and the role of indigenous wetland plants, especially submergents, in contributing to nutrient reduction in wastewater is largely unknown.

Species of Triglochin, commonly known as water ribbons, are fast growing submergent macrophytes. In Western Australia, Triglochin huegelii is mainly a submergent plant but as water recedes, the leaves become emergent. Triglochin huegelii can tolerate a range of water regimes and high nutrient concentrations, and this is useful in wastewater treatment applications. The aims of this present study were to examine the use of Triglochin huegelii for domestic greywater treatment, to compare the effectiveness of this plant with other better known, and more frequently used, emergent macrophytes, and to investigate why Triglochin huegelii is so successful in nutrient accumulation.

A series of investigations using Triglochin huegelii in greywater treatment experiments showed that Triglochin has consistently removed more nitrogen and phosphorus, in all parts of the plant - leaves, tubers and roots, than most other indigenous emergent macrophyte species, including those of Schoenoplectus, Baumea and Juncus which are commonly used for
wastewater nutrient-stripping. In some cases, such as in the leaves, twice as much nitrogen (N) and one and a half times more phosphorus (P) is assimilated in the *Triglochin* tissue. In all parts of the plant there has been an increase in Total N and Total P.

Investigations were conducted using different environmental conditions for the plants. A comparison was made between root zone (substrate-only) and complete pond conditions, with some changes to loading rate and retention times. *Triglochin huegelii* has many practical applications in wastewater management, especially if the level of influent/wastewater can be controlled, thus allowing sufficient time for *Triglochin huegelii* to respond with changed structure and morphology. Proline, a substance known to be produced by plants under stress (such as changing water levels), was detected in *Triglochin huegelii*.

In a pond, the leaves of *Triglochin* can be directly involved in nutrient absorption and assimilation. A study of leaf structure and other aspects of its biology showed that nutrients can easily pass into leaf tissue and then into other regions in the plant. In *Triglochin huegelii*, nitrogen was primarily stored or found in leaves then tubers then roots, while levels of phosphorus were higher in tubers then roots then leaves.

The above-ground:below-ground (AG:BG) ratio of *Triglochin huegelii* also depends on the water regime. For all samples, whether pond or substrate-only, the ratio was 0.84. However, when consideration is given to pond conditions the ratio increases to 1.11. It appears that in pond conditions, and
especially with long retention times, proportionally more above-ground growth (leaves) occurs and in substrate-only conditions, proportionally more biomass is found below-ground, with the number and size of leaves reduced in these plants.

The highest nutrient levels recorded for *Triglochin huegelii* were 11.74 mgP/g and 35.7 mgN/g dry weight. *Triglochin huegelii* has been found to have a protein content of at least 1.7 g/100 g wet weight in the leaves, and less in roots and tubers. *Triglochin huegelii* could have potential as a fodder source because of its high protein content, similar to that of lucerne.

*Triglochin huegelii* seems to remove nitrogen and phosphorus at a greater rate than many other types of aquatic macrophytes. Other parameters such as BOD, Suspended Solids and fecal coliforms were also examined, with reductions of up to 90%, 84% and 99% respectively. The implication is that instead of only planting the perimeter of lagoons, artificial wetlands and constructed basins we should be planting the bulk of the waterway with submergent species such as *Triglochin spp* which are far more effective in stripping nutrients than emergents currently used for that purpose. In addition, systems need to be designed that mimic natural ecosystems, and yet are economical and functional.

This current research can be used as a basis for further study to establish the extent of nutrient removal by *Triglochin huegelii* and its interactions with other macrophytes in polyculture systems.
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Glossary of Terminology and Abbreviations

Aerobic - processes using oxygen.

Anaerobic - no free oxygen or nitrate present (or used in reactions).

Anoxic - no free oxygen, but with nitrate present.

Batch Feeding - intermittent supply of nutrients/water to the system.

Biological Oxygen Demand (BOD) - a measure of organic material in suspension and solution. It is the total amount of oxygen taken up by bacteria as they decompose the organic material.

Black water - wastewater from household toilet systems.

BOD$_5$ - BOD determined over 5 days.

CBOD - carbonaceous BOD.

Chemical Oxygen Demand (COD) - total amount of oxygen required for all types of chemical reactions. Determined by oxidation of matter, usually using potassium dichromate.

Denitrification - reduction of nitrate to nitrogen gas by (denitrifying) bacteria.

DO - dissolved oxygen.

Downflow system - water enters the top of the system and moves downwards.
Ecosystem pond - stable water environment where a variety of different organisms exist. A complex food web, with many interactions, is a common feature of these ponds.

Enteric - intestinal. Organisms which are found in a human’s digestive tract.

Greywater - wastewater from all internal household water fixtures, other than toilet wastes. Also called sullage.

Hydraulic conductivity - the permeability of water to move through a soil, which is dependent on the available pore space and degree of clogging or biomass within it.

Kjeldahl nitrogen - the combination of organic nitrogen and ammonium-nitrogen (generally nitrogen sources other than nitrate and nitrite).

N - nitrogen.

NBOD - nitrogenous BOD.

Nitrification - oxidation of ammonia to nitrate by bacteria (called nitrifying bacteria).

P - phosphorus.

Plug Flow - flow of water where it is assumed that each amount of inflow remains as one unit as it passes through the system.

Rhizosphere - the immediate area/environment surrounding the roots of plants.
**Sessile** - organisms which are permanently attached to an object, stationary.

**SS** - suspended solids.

**TN** - total nitrogen.

**TP** - total phosphorus.

**TSS** - total suspended solids.

**Upflow system** - water enters the bottom of the system and percolates upwards.

**Water regime** - the integration of continuously changing depth over time, and includes the depth, duration, frequency, rate, magnitude, timing and predictability of inundation and drying phases.