IMPACT OF NUTRIENT ENRICHMENT IN A WATERCHESTNUT ECO SYSTEM AT TAKAHAMA-IRI BAY OF LAKE KASUMIGAURA, JAPAN

II. Role of Waterchestnut in Primary Productivity and Nutrient Uptake

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Abstract. Waterchestnut was shown to be one of the most efficient agents to yield photosynthetic products among aquatic plants in littoral vegetation. Though the plant can be an agent to remove nutrient in agricultural and domestic wastes directly through its waterroots to some extent, waterchestnut plays a great role in removing nutrients through its roots from lake sediments to watercolumn of the lake.

Waterchestnut can be choked to death when its leaves are covered completely by the heavy blue-green algal bloom typical in hypereutrophic lakes.

1. Introduction

A lake is accelerated in its process of eutrophication not only by surplus of sedimentation but also by an artificial enrichment (Welch, 1952). At the present time, the littoral shelves of Lake Kasumigaura have been well developed by the active sedimentation to make littoral vegetation gain a foothold, where the littoral vegetation is formed by emerged plants at the water's edge, and floating or submerged plants at the lakeward edge of the shelf. The submerged plants which appeared earlier in succession than floating plants are diminishing according to the progress of the eutrophication, because the floating plants reduce the underwater light intensity for the submerged plants.

The littoral shelf at the head of Takahama-iri Bay shows such a climax stage of the maturing processes of a lake with high standing crop of littoral vegetation. Among this vegetation, waterchestnut (Trapa bispinosa) enlarged its distribution greatly in the last several years.

Waterchestnut has a few layers of floating leaves with buoyant petioles. The leaves spread over the lake surface only a few centimeters deep; i.e., the gas exchange takes place mainly in the atmosphere and not in the hydrosphere. The stems bear a great number of waterroots which prevent horizontal movement of water or provide the nursery grounds for juvenile animals and the substrata for epiphyton. Thus a community composed of a large number of organisms such as plankton, periphyton, nekton and benthos is prospering in the ecosystem of waterchestnut.

Although many works have been published on aquatic plants in the freshwater environment from the point of limnological botany (reviewed in Hutchinson, 1975) or pollution control (reviewed in National Academy of Sciences, 1969; Tourbier and
Pierson, 1976), very few studies have been made on the biology of waterchestnut and its role in pollution control. In a particular environment of Lake Kasumigaura, only Sakurai et al. (1973) have made occasional scientific investigations on a vegetation map of waterchestnut as requested by the Ministry of Construction, although the role of waterchestnut must be great in the ecosystem because of its high standing crop of littoral vegetation there.

2. Methods

Waterchestnut samples were collected at the station (Seki et al., 1979) every few weeks from May to August over the period of their vegetation in 1978. The population density of waterchestnut was determined by a calculation of Leaf Area Index (m² leaf area m⁻² lake surface) divided by the leaf area of individual plant (m² leaf area individual⁻¹). Leaf Area Index (Watson, 1947) was measured by the point quadrat method using pictures of their vegetation in the lake. Daily supply of their vegetative biomass from seeds was measured by the average value of daily decrease of dry weight of several seeds (or nuts).

Nutrient uptake by waterroots or roots of waterchestnut was studied with serial dilutions of a basal medium consisted of 100 μM NaNO₃, 100 μM NaNO₂, 100 μM NH₄Cl, 50 μM KH₂PO₄ and 50 μM MgSO₄ with the addition of a trace Chloramphenicol to depress the microbial activities. The incubation was made at 25°C for several hours both in the dark and light (25 klux). The precise concentrations of nutrients (NO₃, NO₂, NH₄ and PO₄) before and after the incubation were measured by the method of Strickland and Parsons (1968).

The inhibition of waterchestnut growth by the bloom of blue-green algae was examined by comparing photosynthetic and respiratory activities of the leaf samples from regions with and without the heavy bloom. The photosynthesis and respiration by waterchestnut leaves in the atmosphere were measured by the method of Ikusima (1970) using an infrared gas analyzer (Shimadzu URA-3B) for the measurement of CO₂. The respiration by submerged parts of waterchestnut was measured by the ‘light and dark bottle’ method (Strickland and Parsons, 1968) using an infrared gas analyzer (UNOR 2, Hamburg) for the measurement of dissolved CO₂. The daily gross production of waterchestnuts, Pg (gC m⁻² lake surface day⁻¹), in the early and middle August, was determined by a modified formula of Ikusima (1970) as follows:

$$ Pg = AB \sum F_i D^{b/a} \left[ 1 - \frac{1 + a m (i-1) I_{max}}{max} \right]^{l/2} $$

where $A$ is the conversion factor from mg CO₂ to gC (2.73 x 10⁻⁴); $B$ is the conversion factor at 300 to 330 ppm CO₂ (1.10); $F_i$ is the leaf area of the $i$th layer of leaves per lake surface (dm² leaf area m⁻² lake surface); $a$ (klux⁻¹) $b$ (mg CO₂ dm⁻² leaf area h⁻¹ klux⁻¹) are parameters of photosynthesis-light curve; $m$ is the average transmissibility of light through a leaf (0.070); $I_{max}$ is the maximum light intensity at the water surface during the daytime (klux), that was experimentally determined by an equation $I_{max} =$