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A study of the ecological benefits of the green energy landscape fountain

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ABSTRACT

The overdevelopment of the environment in modern times has caused damage to our natural habitat and water resources. The survival of many species has been impacted. The main goal of this study is to explore the effects of green energy landscape fountain (GLF) on ecological preservation. The study site is located on the shore of an open water area within the campus of Mingdao University. The study site consists of three water tanks, buried inland, 1.5 m away from the shoreline. An ecological comparison study was performed on the quality of water between the three tanks of water. GLF is a floating island sized 60 cm × 60 cm made of PVC pipes with electricity supplied by solar panels. Changes in numbers of species were documented over a period of one year spanning 4 seasons in 3 different bodies of water. The results showed that the water with GLF installed had more species of organisms. 10 different species of organisms such as *Tetragnatha maxillosa, Polyrhachis dives, Araneus inustus, Ischnura senegalensis, Diaea subdola* were found in the water with GLF installed. 7 species often used as benchmark indicators of water pollution were found in water without GLF installed. The findings demonstrate the benefits of GLF on improving species diversity and the quality of water. This study also provides information which can be applied on landscape architecture, architecture and ecology design and engineering in the future.

1. Introduction

When a floating island is disconnected from land, a separate ecosystem with its own food chain is established from flying insects, insect-trapping spiders, fishes, amphibians, and amphibian-feeding fishes and birds (Hsi Liu Environmental Greening Foundation, 2009). According to Environmental Protection Administration, R.O.C. (2013), the people of Thao tribe residing in the Sun Moon Lake area pioneered the building of artificial floating islands in Taiwan. They used bamboo, covered with grass sheets, as floating frames to grow rice paddies, known as “floating farmland”. A floating island is formed when the overgrowth of water plants in a body of water continuously extend their growth to the water surface, and subsequently, plants from the island connected to land die or break off (Hsi Liu Environmental Greening Foundation, 2009). Artificial floating islands (AFI) were placed in lakes in New Hampshire, USA, as early as 1900 to provide nesting grounds and habitat for birds of the Gaviidae family (AFI study Sample, 2000). In Asia, the earliest artificial floating structure was recorded in Japan in 1920. Branches were tied together and placed in lakes, providing grounds for fish to lay eggs (Hirose, 1997). Nakamura and Mueller (2008) indicated that floating islands helped contain the spread of pollution at water entry points. Furthermore, it reduced the speed of water flow, and allowed pollutants to be intercepted and settled through the plants roots and body. Floating islands on water surface protect shorelines from erosion by reducing the energy and water dissipation due to water waves (Takagi, 1996). Also, plants in the AFI can remove harmful metals from the water helping to purify the water and reduce pollution at water sources (Headley and Tanner, 2006; Bankston et al., 2002; Wang and David, 2013).

Both Fonder and Headley (2010) and the Environmental Protection Administration, R.O.C. (2013) pointed out that one approach to constructing an AFI is to grow plants on floating objects. During plant growth, plant roots below the water surface will directly absorb carbon-based organic compounds, nitrogen, phosphorous and other nutrients. As a result, concentrations of nitrogen and phosphorus are lowered. Plants can be manipulated to achieve a maximization of the absorption rate within the island. (Stewart et al., 2008). Some of the advantages of AFIs are that very little land is required and the costs are low. Suspended solids in the

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water are removed via a physical reaction with the plant roots in the water (Wen and Recknagel, 2002; Zhao et al., 2012 Chang et al., 2012).

Other benefits of AFIs include providing habitats for living organisms and for ecological conservation. AFIs increase habitat areas for water organisms, and act as sanctuaries for fishes, birds, insects, and amphibians. Successful examples of using AFIs to restore bird population have been reported in Canada. (Will and Crawford, 1970; Fager and York, 1975; Payne, 1992; Hiraoka, 1996). Cheng (2006) indicated that as shoreline protection to dissipate water waves, AFIs are not affected by the depth of water. Their construction is easy and their cost is low. At the same time, they easily blend in with surrounding landscape. Ohsima et al. (2001) explained that AFIs can suppress growth of phytoplankton and algae, and prevent eutrophication. They also enrich the aquatic ecosystem. Furthermore, they elevate the overall landscape aesthetic, while removing pollutants from the water. Piper et al. (2002) placed AFIs in 26 lakes. The success rate of egg hatching to fledgling between the AFIs and the natural nests were 69% and 32% respectively. Both You (2002) and Tien and Wang (2004) indicated that water pollution levels and overall water quality could be analyzed via typical bio-indicators found in the water.

Aquatic plants are one of the components of AFI. According to the Environmental Protection Administration, R.O.C. (2013), a total of 48 different species of floating, emerged and submerged aquatic plants, are commonly found in wetlands. Among the plants found *Bacopa monnieri* (L.) Wettst. is the most suitable for AFI. The Environmental Protection Bureau (2005) pointed out that suitable plants should demonstrate a high adaptability to the environment and show strong tolerance and adsorption to pollutants. Furthermore, the Environmental Protection Administration, R.O.C. (2013) mentioned that floating support of *B. monnieri* (L.) Wettst. can help guide plants whose roots require adherence to the ground, in order to grow, to migrate from the shore to the water surface, helping to form a grass island. Shih (2006) mentioned that *B. monnieri* (L.) Wettst. alone has 5.1% and 7.6% adsorption rate of nitrogen and phosphorous respectively. Through the breathing of its roots, *Ludwigia* (×) *taiwanensis* allows the adherence of micro-organisms and prevents overgrowth of algae, while purifying water. Dai and Chiang (2008) revealed that *Ruellia brittoniana* has average removal rates of 56.49% for nitrogen and 15.58% for phosphorous. *Angelonia angustifolia* is very suitable for AFI and is easy to grow because it prefers an environment that is warm, wet, sunny, and with good water drainage.

One of the characteristics of charcoal is its high absorption of liquid and gas. It is used to purify water, eliminate odor and moisture. Also, it was reported by Pehlivan and Kahraman (2011) and Lin (2004) that when placed at the bottom of water ditches, charcoal has the ability to filter out contaminants. Kazuo (1987) indicated that the greater the surface area of the filtering media, the better it can provide for the growth of micro-organisms. An example is the common hairbrush. It provides a large growing surface area and is reusable. Hou and Gan (2004) compared 7 common filter media sold on the market. After cost consideration, different hydraulic retention times, removal efficiency of solids and total ammonia nitrogen, the hairbrush had the highest unit volume efficiency rate (g/m^3/day). An oxygen aerator can be used for the purification of water. The main purpose of an aerator in a fishpond is to improve the overall water quality. Water with a low dissolved oxygen (DO) level not only interrupts fish migration, in some cases, it causes death (Horne, 2001). The studies above all mentioned the benefits of AFTs toward water purification and ecological conservation.

2. Materials and methods

2.1. Study area

The location of this experiment was in the orchard of Mingdao University campus in Xizhou Township of Changhua County in Taiwan, E23°86′79″, N120°49′33″. Three circular water-holding holes, spaced 20 cm apart, with the dimensions of 1.7 m in diameter and 2 m in depth, were dug 1.5 m in-land from the shoreline of an open body of water. Water tanks of equal size were then placed into the holes to prevent water loss from seepage through soil. 6 samples of water labeled A through F were divided. Samples D through F were compared for ecological benefits. Sample A consisted of water from the water purification station; Sample B was water from Lize Lake (on campus). Sample C was

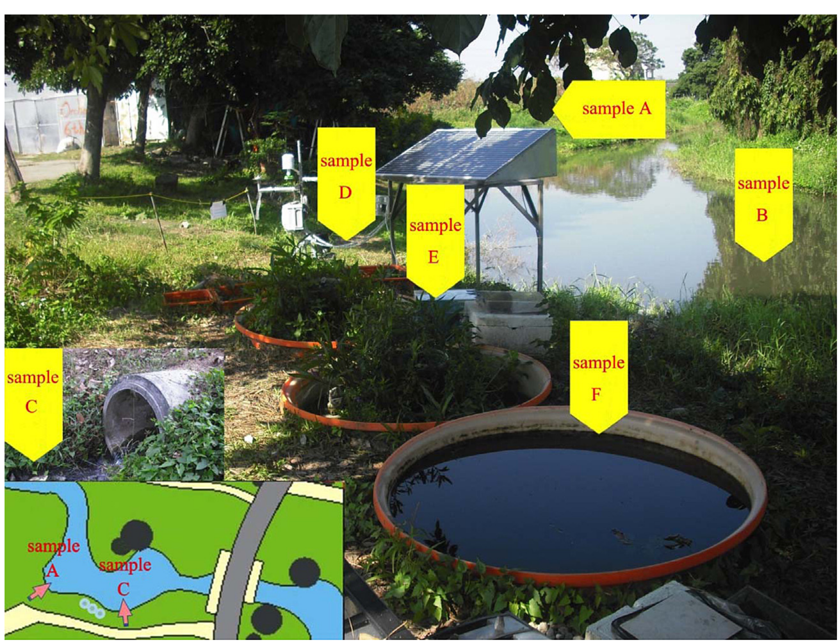

Fig. 1. Study area.