Recent Trends in Civil Engineering and Built Environment Vol. 4 No. 1 (2023) 394-402

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

A Modified Design of Mobile Water Plant Remover Device

Muhammad Zaki Alias[1], Siti Hidayah Abu Talib[1]*

[1]Faculty of Civil Engineering and Build Environment
Universiti Tun Hussein Onn Malaysia, 86400, Batu Pahat Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rtcebe.2023.04.01.042
Received 06 January 2022; Accepted 15 January 2023; Available online 01 May 2023

Abstract: Invasive aquatic plants usually grow in lakes that are not the original habitat of invasive plants in the area. These invasive aquatic plants spread to new areas and can live anywhere in the water, whether emerging, submerged, or floating. Therefore, lake conservation should be done in a planned manner. The aim of the research is to find a solution to the university's concerns with lake clean-up. The problem of rapidly growing invasive plants has caused the university to incur high cleaning costs. The university hired a contractor to clean the lake and the method used was manual cleaning where the workers boarded a boat and cut plants using blades. Therefore, this study was conducted to modify the design of the subsurface water device and produce a user-friendly prototype device for plant removal. The prototype is designed with two combinations of tools available namely the Razer Weed and the Razer Rake. This prototype was tested for its effectiveness in a designated study area with an area of 4000m^2. At the end of this study, it was found that the differences between the use of manual and prototype affect the time and cost where is the time required by the prototype is 15 days longer with an area of 120m^2 per day compared to the use of manual which takes 18 days for an area of 222m^2 per day to clean invasive aquatic plants. The cost used is lower than the manual method and it is user-friendly beside can be used by the university in the future.

Keywords: Invasive Aquatic Plant, Portable Harvester, Plant Removal, Modified Method.

1. Introduction

Malaysia's lakes appeal to naturalists, botanists, and zoologists as well as leisure, casual wildlife, and outdoor enthusiasts. This is due to the fact that the lakes are home to a diverse range of flora and fauna, with more habitats waiting to be found. Malaysia's natural lakes are made up of tin-mine ponds from the past. Some of these bodies of water are formed as a result of reservoir development and hydroelectric power generators, as well as the damming of many rivers [1]. Aquatic plants influence and interact with the hydrological, geomorphological, and physicochemical ecosystems, as well as a broad variety of other species, from microbes to vertebrates, by supplying habitat and food [2]. Aquatic plants must have unique adaptations in order to survive submerged in water or on the water's surface.

Corresponding author: hidayaht@uthm.edu.my

Aquatic plants may only grow in water or in soils that are often flooded. As a result, they are common wetland species [3].

The excessive growth of aquatic plants can have negative effects on the lake ecosystem and water quality. Large aggregations of plants covering the water surface limit light penetration to prevent water aeration and turbidity because increased turbidity causes a decrease in the amount of light for photosynthesis. Turbidity can also increase water temperature because suspended particles absorb more heat. These factors lead to a decrease in dissolved oxygen. Turbidity can also affect how well aquatic life can see or function underwater. Excessive turbidity is known to clog the gills of fish, interfere with their ability to find food, and bury bottom-dwelling creatures and eggs [4]. Universiti Tun Hussein Onn Malaysia (UTHM) does the maintenance work with removing the invasive plants in the lake around the university using the manual method where workers are on a boat and use a machete as a tool to cut invasive plants manually. Hence, the purpose of this study is to develop a prototype that can help the work of cleaning invasive plants in UTHM lake.

2. Literature Review

2.1 Aquatic plants become invasive

Invasiveness is typically determined by the combination of the local ecosystem factors and foreign aquatic plant qualities, which decide whether invasive aquatic plants will develop excessively [5]. Invasion is more likely in disturbed systems [6] in part because disruption increases resource availability fluctuations. The mechanical removal of most or all macrophytes, physically creates open spaces and speeds up the flow of nutrients. Similarly, waters that were formerly dominated by phytoplankton now provide open habitats for invasive aquatic plants to colonize effectively [7]. The biotic resistance given by native plants is another aspect that influences invasion success [8]. Other factors that contribute to the growth of invasive aquatic plants include competition, enemy release, the development of better competitive ability, allelopathy, unfilled niches, changeable resources, opportunity windows, and propagule pressure [9],[10],[11].

2.2 Effect of Invasive Aquatic Plant on the Environment

The majority of the negative effects are caused by the invasive aquatic plant's fast growth, which produces large amounts of biomass and so covers large areas of natural open water [12]. Water bodies with invasive aquatic plants have higher turbidity, greater chemical oxygen demand (COD), lower pH, lower dissolved oxygen (DO), fewer nitrates, and a greater amount of chlorophyll, according to [13]. The presence of invasive aquatic plants on the water surface allows vectors of various human illnesses, such as bilharzia (schistosomiasis), intermediate snail hosts, and most mosquito vectors, which include malaria, filariasis, and encephalitis transmission [14]. Moreover, according to Matthew [12], invasive aquatic vegetation has offered shelter for lurking snakes and crocodiles. While invasive aquatic plants on the water surface have choked streams and hampered water traffic [13].

2.3 Invasive Aquatic Plants Management Control

There are two techniques to remove invasive aquatic plants and other pollutants from lakes adopted by (UTHM). Machinery is one of the techniques such as using excavator and backhoe. Excavators can be used to harvest floating plants or to excavate rooted floating leaved, submerged, and emerged plants with rhizomatous mats. Used in narrow waterways such as ditches, channels, drainage or irrigation systems, ponds, or small rivers [15].

Another approach is a manual method in which personnel ride a boat and use a sickle to physically cut the invasive aquatic plant and remove the plants. This method is most commonly performed on emergent plants. If there are not too many invasive plants in the lakes, the manual method will be applied. Because of the ephemeral nature of the impact, this technique needs ongoing monitoring [15].

3. Materials and Methods

3.1 Site Selection

For this study, the lake located in the middle of the university area near the examination hall (F2) and lecture hall (G3) were selected which is the Teknologi Lake. The total area of this lake is a 4067.18-meter square consisting of 343.77 m perimeters with a water level is 1.136 meters. The location was chosen because the invasive plant is cleaned and uses the traditional method of cutting invasive aquatic plants. This lake has the characteristics of invasive aquatic plants that this reason makes this lake suitable to be used as a study area. The method used during invasive plant cleaning on the lake, the tools used for cutting, the duration used to solve the cleaning by using the appropriate manual methods were observed.

3.2 Designing Process

The prototype was developed for the removal of invasive plants refers to two products already on the market which are Weed Razer and Razer Rake which are often used to clean lake areas from invasive plants in their own way. Weed Razer products perform plant cutting in the water while Razer Rake products scratch the soil base to remove plant roots and both of these products perform the cutting and scratching method by pulling the product to the lakeshore. The distance of this tool could be determined based on the worker throwing strength. These two products have their own limitations in terms of distance to cut invasive plants and cannot collect invasive plants that have been cut. Therefore, by combining these two products can cut and collect once the invasive plants have been cut and add some improvements in terms of prototype distance can do the cutting in the lake. Figure 1 shows a 3D view of a concept design for a prototype created through research using AutoCAD software.

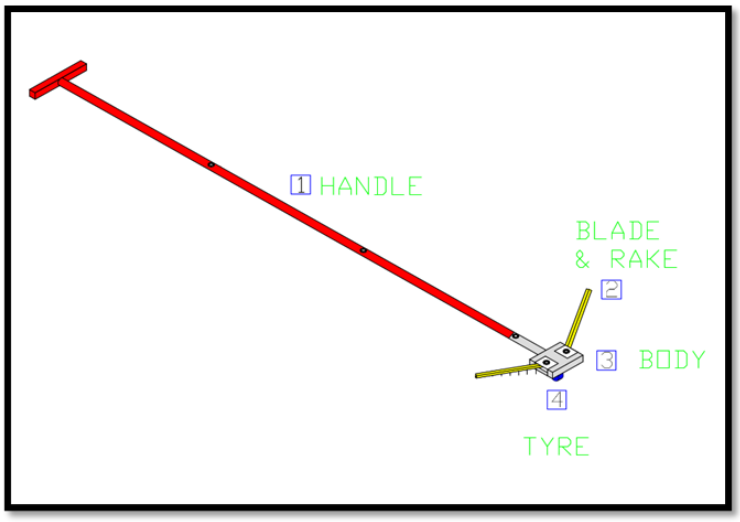


Figure 1: Idea design of the prototype in 3D view

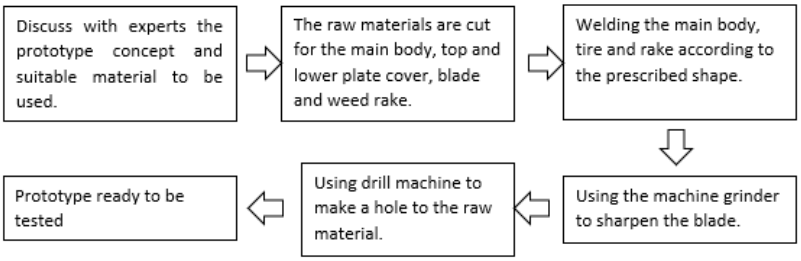
Basically, the handle pushes and pulls the product to the bottom of the lake with the help of wheels connected to the main body which makes the product easy to move. This prototype has an extendable handle that can reach a size of 1-meter up to 3-meter. As the product moves to the bottom of the lake, the blade on the left and right serves to cut invasive aquatic plants that are exposed to the blades of the plants until they are cut off. Next, the product was pulled out of the lake. At the same time, the rake under the blade makes the blade change direction by measurement of 60 degrees from the shape when pushed into the water with the aid of the rake pulling the plant that is at the water.

3.3 Selection Materials

The selection of product materials is made based on the characteristics of the study area that is in contact with water and products was below the water surface. In this research, the materials used were stainless steel, galvanized pipe, steel plate and tire rubber. This material is waterproof, lightweight and durable materials to be on the subsurface.

3.4 Prototype Development

The prototype development process is based on the review of researcher studies. Skillful procedures and safety precautions are needed during this fabrication process. Flowchart 1 shows the summarized fabrication process.



Flowchart 1: Prototype development process

3.5 On-Site Testing

Once the prototype is completed, the prototype was tested in the study area of Teknologi Lake around UTHM campus to obtain information on the function and effectiveness of the prototype. Due to the large area of the lake, the area to test the product could not be done the whole lake. So, some of the selected sections around the lake are measured 1m x 1m. Two types of tests were performed on the prototype. First, test the product while on land. This test is performed to test the effectiveness of the product moving on land while being pushed and pulled. Second, test the effectiveness of cutting and scraping. Figure 2 shows a prototype ready to be tasted.

(a) (b)

Figure 2: Prototype design; (a) before installation prototype, (b) after installed prototype

4. Results and Discussion

Figure 3 (a) shows the number of lotuses before the prototype was tested. If look at the study area that has been marked in Figure 3 (a), lotus plants fill the area and around the area that has been marked

also has a large number of lotus plants. While the prototype was tested, to 1m x 1m area which made the time taken to complete this area be 4 minutes performed by a worker. Instead of 4 minutes per $1m^2$, the area that can be cleaned in an hour are $15m^2$. Based on Figure 4, after the prototype was completed being tested, the lotus plant was successfully raised to land using the prototype with the value of the total area minus the value of the shaded area estimated at 78% as shown in Table 1. The rest floats after cutting and is not exposed to the blades and weed rake was raised.

(a) (b)

Figure 3: (a) The lotus plant before the prototype was tested, (b) Study area after using the prototype

Table 1: Percentage of area that had been cleared from figure 4

Total area (red line)	$1m^2$
Shaded area (yellow line)	1. 0.3m x 0.2m = 0.06 m^2 2. 0.8m x 0.2m = 0.16 m^2
Clean area, %	78%

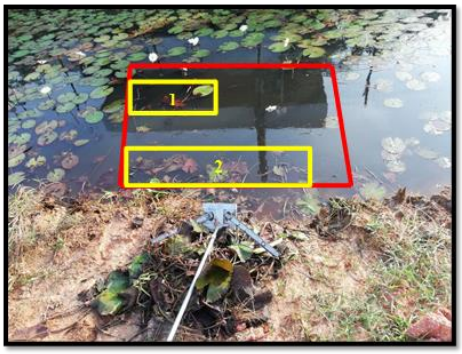


Figure 4: The number of successful lotus plants was raised using prototypes

4.1 Interview with Cleaning Contractor

The data or information gathered by the researcher following the interview session is shown in Table 2. The researcher was analyzed this data in order to come up with a solution to this problem.

Table 2: Data gets from the interview

Question	Findings
What is the method used in cutting invasive aquatic plants at one of the UTHM lakes?	Use the manual method
What tools are used to cutting invasive aquatic plants at the lake?	Use a boat to an invasive plant area Use a blade to cut invasive plants Apply the net for plants lift that has been cut
How much is the period allocated to remove all invasive aquatic plants from the lake?	Approximately 18 days for 4000 m^2 area in one of UTHM lakes
How many workers and salary do cutting work of invasive aquatic plants?	2 workers for one day Approximately RM 60 to RM 70 per day

4.2 Discussion

4.2.1 Comparison of methods that have been used for manual and prototype in cutting invasive aquatic plants

According to the findings, it can be concluded prototype model seem can assist in the removal of invasive aquatic plants compare to the manual method. However, the prototype model has a few limitations whereby the maximum distance of the prototype may go depending on the handle length and requires a long area to pull out the prototype if the prototype handle is not opened one by one according to the length of the handle installed.

Table 3: Comparison method had been used

	Manual	Prototype
Method	Use a boat to an invasive plant area	Push and pull the prototype beside the lake
Equipment	Use a blade to cut invasive plants Apply the net for plants lift that has been cut	Prototype blades cut invasive plants The prototype rake pulls out the roots of invasive plants
No. of worker	2 workers at a time	1 worker at a time

4.2.2 Comparison time is taken for cutting invasive aquatic plants between manual and prototype method

The working period for one day is around 8 hours. The time required to clean invasive plants using the manual method is 18 days with an area of 222m^2 per day. In addition, the prototype method takes 4 minutes to clear an area of 1m x 1m which will take 33 days with 1 day equivalent to 120 m^2. The

time taken for the prototype to finish the work for the 4000square lake area is fifteen days extra compared to the manual method as shown in Table 4. In comparison to the lake area used in the manual approach, the research area is expected to be fully covered in lotus plants. As a result, it may take longer to clean up after using this prototype.

Table 4: Time consuming between manual and prototype

	Manual method	Prototype method
Area	$4000m^2$	$4000m^2$
Time Taken	18 days	33 days
Area (per days)	$222m^2$	$120m^2$

4.2.3 Comparison labour cost for cutting invasive aquatic plants between manual and prototype method

Depending on the outcome, the cost of using the prototype model is lower than the manual method because only one person is responsible even if the time taken is more than 15 days for the cleaning work. The manual method has a high maintenance cost due to the need for more boat service as shown in Table 5.

Table 5: Cost estimation between manual and prototype

	Manual method	Prototype method
No. of worker	2 workers at a time	1 worker at a time
Salary (per day)	RM 60.00	RM 60.00
Other cost		
Boat towing sharpen the blade	RM 100.00 RM 5.00	 RM 5.00
Days needed for $4000m^2$	18 days	33 days
Total cost	RM 2265.00	RM 1985.00

5. Conclusion

Based on the results obtained, the prototype design was based on a combination of two invasive plant cutting and clawing equipment called Weed Razer and Rake Razer. This prototype is designed to remove plants that have grown below the water's surface. Originally, the distance of this tool could be determined based on the user's throwing strength. Thus, modification of this prototype's distance can be expanded once it has been adjusted by adding handles according to the user's preferences. Furthermore, with a functional tyre under the main body that can push and pull this prototype into the water, this design assists in simultaneously cutting and scratching plant roots. However, the time taken to clean an area of 4000 m^2 similar to the manual method by using the prototype took 33 days compared to 18 days using the manual method. This is because while pushing the prototype made in the study

area it takes more time because the scraper on the prototype is stuck on the rooted plant which makes it difficult for the prototype to be pushed. Supposedly, the scraper claws and pulls as the prototype are pulled back.

This prototype is portable, making it ideal for clearing the lake of invasive plants. Furthermore, by simply applying bolts and nuts to connect each component, the installation of each component takes a short time. It's also quite simple to use this tool by just pushing and pulling the prototype into the water. This product's maintenance is simple, requiring only the replacement of damaged components such as blades and scrapers and the installation of new ones. Besides, from the results of the study found handles are attached with a 1-meter measurement per pipe, the lake edge land area will also need to be large to pull and push if the prototype is used to clear invasive plants across a large area.

Acknowledgement

The authors would also like to thank the Faculty of Civil Engineering and Built Enviroment, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Noor Anira Hj Wan Ali, Wan, Norhafizah Abdul Rahman, Marina Abdullah, and Nor Izana Mohd Shobri. 2015. "The Potential of Lake in Generating the Urban Community Development. Case Study: Putrajaya Lake, Federal of Putrajaya," no. October. http://www.ppj.gov.my.

[2] Wood, K. A., O'Hare, M. T., McDonald, C., Searle, K. R., Daunt, F., & Stillman, R. A. (2016). Herbivore regulation of plant abundance in aquatic ecosystems. Biological Reviews, 92(2), 1128–1141. https://doi.org/10.1111/brv.12272

[3] Willby, N. J. (2007). Managing invasive aquatic plants: problems and prospects. Aquatic Conservation: Marine and Freshwater Ecosystems, 17(7), 659–665. https://doi.org/10.1002/aqc.913

[4] ALEXANDER, K. FOSTER, G.N. AND SANDERSON, N., 2010. Good ecological status of inland waterbodies: fencing of riverbanks is not 'good for biodiversity'. British Wildlife, 21 (5), 326-332.

[5] Alpert, P., Bone, E., & Holzapfel, C. (2000). Invasiveness, invasibility and the role of environmental stress in the spread of non-native plants. Perspectives in Plant Ecology, Evolution and Systematics, 3(1), 52–66. https://doi.org/10.1078/1433-8319-00004

[6] MacDougall, A.S., Turkington, R., 2005. Are invasive species the drivers or passengers of change in degraded ecosystems? Ecology 86, 42–55.

[7] Hussner, A. (2010). Growth response and root system development of the invasive Ludwigia grandifl ora and Ludwigia peploides to nutrient availability and water level. Fundamental and Applied Limnology, 177(3), 189–196. https://doi.org/10.1127/1863-9135/2010/0177-0189

[8] Levine, J. M., Adler, P. B., & Yelenik, S. G. (2004). A meta-analysis of biotic resistance to exotic plant invasions. Ecology Letters, 7(10), 975–989. https://doi.org/10.1111/j.1461-0248.2004.00657.x

[9] Riis, T., Lambertini, C., Olesen, B., Clayton, J. S., Brix, H., & Sorrell, B. K. (2010). Invasion strategies in clonal aquatic plants: are phenotypic differences caused by phenotypic plasticity or local adaptation? Annals of Botany, 106(5), 813–822. https://doi.org/10.1093/aob/mcq176

[10] Fleming, J.P., Dibble, E.D., 2015. Ecological mechanisms of invasion success in aquatic macrophytes. Hydrobiologia 746, 23–37.

[11] Hussner, A., Hofstra, D., Jahns, P., & Clayton, J. (2015). Response capacity to CO2 depletion rather than temperature and light effects explain the growth success of three alien Hydrocharitaceae compared with native Myriophyllum triphyllum in New Zealand. Aquatic Botany, 120, 205–211.

[12] Matthew Cock. (2001). Problem Caused by Water Hyacinth as an Invasive Alien Species. Invasive Alien Species: A Toolkit of Best Preventation and Management Practices, 171.

[13] Dersseh, M. G., Melesse, A. M., Tilahun, S. A., Abate, M., & Dagnew, D. C. (2017). Water hyacinth: review of its impacts on hydrology and ecosystem services – Lessons for management of Lake Tana. Extreme Hyacinth and Climate Variability, 1824, 238-251.

[14] Gezie, A., Assefa, W. W., Getnet, B., Anteneh, W., Dejen, E., & Mereta, S. T. (2018). Potential impacts of water hyacinth invasion and management on water quality and human health in Lake Tana watershed, Northwest Ethiopia. Biological Invasions, 20(9), 2517–2534. https://doi.org/10.1007/s10530-018-1717-0

[15] Pot, R., 2003. Invasion and management of Floating Pennywort (Hydrocotyle ranunculoides L.f.) and some other alien species in the Netherlands. In: Caffrey, J.M., Dutartre, A., Haury, J., Murphy, K.M., Wade, P.M. (Eds.), Proceedings of the 11 EWRS International Symposium on Aquatic Weeds, 435–438.