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The Development of Seabin Boat As a Waste Collector for Marine Pollution

Adnin Afifi Nawi[1]*, Farisya Nabella Sarudin[1], Nurul Lisa Zulfakri[1], Ahmad Zafran Mohamad Tajudin[1]

[1]Department of Science and Mathematics, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, KM1, Jalan Panchor, Pagoh 84600 Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: 70 percent of the surface of the earth is covered by the ocean and it is our responsibility to save it from pollution. Over the years, marine pollution has become a serious issue especially due to the mismanagement of plastic waste. In this project, a prototype of a seabin boat that could collect trash on the water surface was developed. The working performance of the boat in terms of buoyancy, stability, the speed of the boat, and energy supply were also tested. This project was started with the design of the prototype. Then the body of the prototype was set up by using styrofoam which is the main material for this project. Besides that, a table mat was used to act as a conveyer with the power of 9 V batteries and 6 V motors. The working performance of the boat in terms of buoyancy, stability, speed of the boat, and energy supply was tested in a pool in UTHM Pagoh. Archimede's principle was also applied to do the testing. Based on the result obtained, the boat could perform well in terms of buoyancy, stability, speed, and energy supply. The boat could collect a 240 g load of weight with maximum speed, 0.043m/s, and energy capacity equals 500 mAh. Further research needs to be conducted to improve the performance of the prototype.

Keywords: Seabin, Water Cleaning Boat, Waste Collector, Ocean Pollutant, Boat Design

1. Introduction

Marine pollution specifically in plastics waste has become a crucial problem in our country since Malaysia was ranked eighth in the world for global plastic polluter of the oceans [1]. Marine pollution can reduce the total water supply significantly because the value of treating impure waters is too high. Urbanization contributes to increased marine pollution problems, especially sedimentation, solid waste, rubbish, and organic pollution. For instance, if the waste is not disposed of in proper ways, almost all discarded items such as plastic bags, bottles, and straws can reach the marine. Six countries including China, Indonesia, Malaysia, Philippines, Thailand, and Vietnam are the ones who contribute 60 percent of 8 million tonnes of plastic waste that enter the world's marine each year. Based on the analysis in

*Corresponding author: adnin@uthm.edu.my

terms of annual per-capita plastic packaging consumption, Malaysia ranked highest among six countries which are about one person produce 16.8 kg of plastic waste [2]. The marine pollution overwhelmed all the Malaysians since domestic waste disposal could cause a more vital impact on marine pollution.

8 million metric tonnes of plastic go into the marine every year. Eight million metric tonnes was ended up in the marine every year and this problem making us take action since the marine cannot wait for a long terms solution. It is about the world that produces 2.5 billion metric tonnes of solid waste and 275 million metric tonnes of that are plastics waste [3]. Our marine is in trouble with the critical amount. Back in 2010 at the worldwide level, China had mismanaged 8.8 million metric tonnes of waste and 3.53M metric tonnes ended up in the oceans followed by Indonesia with 3.2M tonnes of mismanaged waste and 1.2M ending up in the oceans with 264 million population in the country [4]. Around 0.90 million tonnes of plastic waste that Malaysia had mismanaged in 2010 which is 0.14 to 0.37 million tonnes ended up in the marine [5].

To reduce marine pollution, previous researchers have developed a tool that can collect trash on the water surface. This includes The Seabin in [6], Water Trash Collecter (WTC) in [7], and The Rubbish Collecting System in [8]. All of these tools collecting the solid waste using a concept where water will flow in then streams out through the base of the container and up into the pump on the dock [9]. Therefore, in this study, a prototype of seabin boat that can remove floating solid trash at the water surface was developed and the working performance of the prototype in terms of buoyancy, stability, speed, and energy supply was tested.

2. Materials and Methods

2.1 Materials and Equipment

Materials used in this project include table mat, styrofoam, propeller, can bottle, ice cream sticks, two 6 V D.C motor, two 1.2 V D.C motor, three 9 V battery and battery holder, 6 V Solar panel, wire, and switch. Meanwhile, this project's equipment is a scissor, hot glue gun 60 W and stick, strong paper glue, ruler, pen, cutter, soldering iron, and tin soldering wire.

2.2 Boat setup

The process to develop the prototype took about two weeks and the testing on the prototype took about one week. The dimension of this boat is $37 \times 29 \times 24$ cm and the net weight of the boat is 0.68 kg. The boat that has been developed can be seen in Figure 1 below:

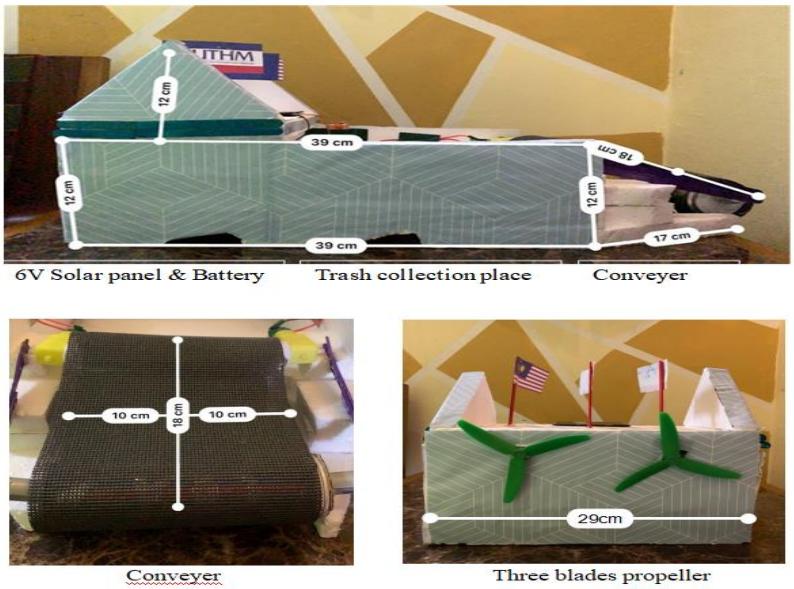

Figure 1: Side, back and front view model of the boat

2.3 Testing the working performance of seabin boat

There are four parameters were tested on the prototype. The first parameter to be measured is the buoyancy of the boat. The main material for building a boat for this project is styrofoam. The density of styrofoam is 0.05 g/cm^3 is less than the density of water (997 kg/m^3). The weight of the boat was calculated to measure this parameter which is the buoyancy of the boat. For calculating the total weight of styrofoam as the following:

$$d = \frac{M}{V} \qquad \text{Eq. 1}$$

where d is density, M is mass or weight and V is volume. The weight of styrofoam will be estimated as in **Table 1** to ensure the suitable weight for a boat.

Table 1: The volume and weight of styrofoam

Volume of styrofoam (cm^3)	Weight of styrofoam (g)
10 x 52 x 10	260
12 x 54 x 10	324
14 x 56 x 10	392

The second parameter is the efficiency of the boat to carry the loads. For this parameter, the amount of load was estimated based on the weight of the boat. The amount of load plays a role to ensure that the boat remains stable because the amount of load would affect the boat's weight, which is related to Archimedes' principle. Therefore, the weight of the boat needs to maintain as the water is displaced to keep it floating. The amount of load as stated in **Table 2**.

Table 2: Weight of boat and the amount of load will be carry

Weight of boat (g)	Amount of load (g)
200	80
400	100
600	120

Next, the third parameter is their speed to maintain the quality of this project. The speed of the boat depends on the quality of the motor and propeller. Direct current motor (DC) was for this prototype. The things to be tested by the use of a DC motor to compute the speed of a boat is the rotation per minute (RPM) and the voltage input. Then the boat was tested with three and four-blade propeller depending upon the speed.

Finally, the last parameter is energy supply. This part is very important to ensure the boat is working correctly. The testing was conducted by using a variable voltage of battery such as 1.5 V, 3 V, 6 V, and 9 V to running the motor to ensure the boat working. This is because the voltage of solar panels use depends on the total voltage of the battery to avoid the battery from overcharge and the circuit short due to overheating.

3. Results and Discussion

In this section, the result obtained in the testing will be discussed. Four experiments were conducted to evaluate all the parameters tested for this prototype of seabin boat. **Figure 2** shows the prototype was tested on the pool at University Tun Hussein Onn Malaysia, Pagoh. The prototype was departed at the surface water to evaluate the parameter during the trash collection task. During the experiment, the prototype worked well in the pool without any problem after the circuit switch was turned on. **Figure 3** shows the connection of motor, batteries, switch, and solar panel in one circuit.

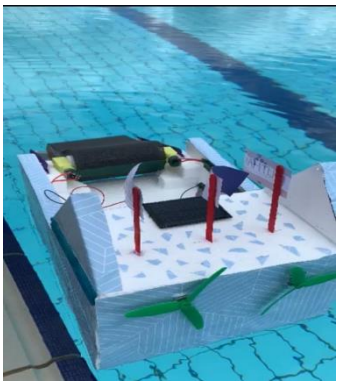

Figure 2: The prototype was tested in pool

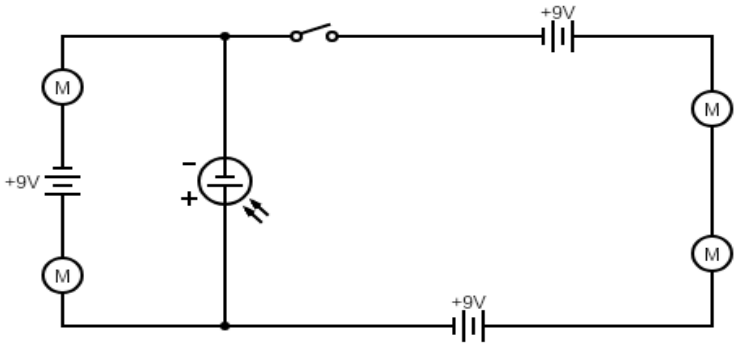

Figure 3: The circuit diagram of the seabin boat

3.1 Result of testing on the working performance of the boat

3.1.1 Parameter 1: The buoyancy of the boat

This prototype was tested in water which is density is 997kg/m³ higher than the density of styrofoam (0.68 kg/m³). This test was succeed as the boat float on the water surface without any probability to sink. To further strengthen that statement is the total buoyancy force of boat (1.33×10^{6} Newtons) is more that their weight (0.68 kg/m³), the boat able to float. **Table 3** shows the weight, buoyancy force and other info of the boat.

Table 3: Volume, weight, density, and buoyancy force of the boat

Volume	135.72 m³
Weight	0.68 kg/m³
Density	5×10^{-3} kg / m³
Buoyancy Force	F = V × Df × Fg F = 0.026 m³ × 997 kg/m³ × 9.81 N/ kg F = 1.33×10^{6} Newtons

The boat also floats upright in stable equilibrium, which is in equilibrium under the action of two equal and opposite forces. The weight, W, acting vertically through its center of gravity, G, and the buoyancy force, of equal magnitude W, acting vertically upwards at the center of buoyancy, B. This center of buoyancy is located at the center of gravity of the fluid displaced by the vessel. To prove it in equilibrium, the point G and B lie in the same vertical line as shown in **Figure 4**.

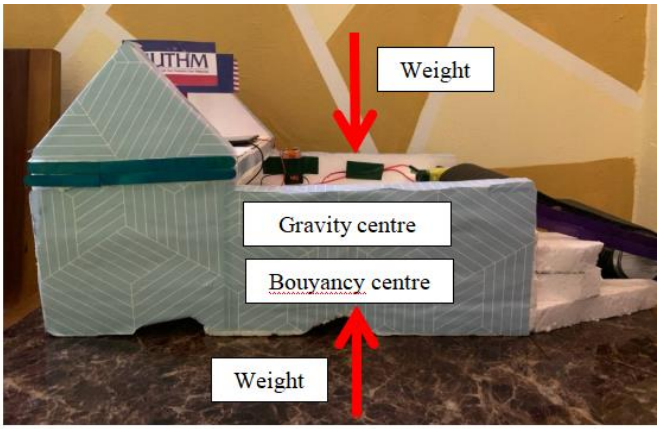

Figure 4: The direction of weight force, gravity force, and the buoyancy force

3.1.2 Parameter 2: The efficiency of the boat to carry the trash

Next, the efficiency of the boat to carry the trash was tested. For this prototype, the size of the base is 29 cm wide and 39 cm long, and 12 cm in height. The net weight of the boat is 0.68 kg and the boat was able to carry the trash more than 120 g as in the testing of the seabin boat. The total weight of the load was measured by the time taken to show the ability of the boat to collect the trash at a certain time. As a result, the boat still maintains its stability after the load's weight reaches the highest capacity, as in **Table 4**.

Table 4: Time taken for boat collect the trash

Times (m)	Weight of trash (g)
2	60
4	120
6	180
8	240

3.1.3 Parameter 3: The speed of the boat

In this prototype, a 6 V DC motor and 100 RPM are used to operate a conveyor and three blades propeller to helps running the boat. The speed of the boat was tested in the pool by manually calculated based on the distance measured and time taken. **Table 5** describes the path taken by the boat during the collection task. During the first test, the boat moved 3 m away from the poolside that traveling at speed of 0.043 m/s for 70 seconds. During the second test, the boat had travel for 140 seconds at a speed 0.036 m/s. During the last test, the battery has overheated so the electricity supply was reduced. The boat was able to move 7m away at speed of 0.033 m/s for 210 seconds. Table 5 below shows the distance and the time taken recorded during the experiment.

Table 5: The distance and time taken to calculate the speed of the boat

Distance (m)	Time (s)	Speed (m/s)
3.0	70.0	0.043
5.0	140.0	0.036
7.0	210.0	0.033

3.1.4 Parameter 4: The energy supply

For this prototype, 9 V batteries and 6 V solar panels were used as energy supply. The fully charging for a 6 V solar panel with a 9 V battery is about 7.2 voltage and it shows the solar panel could pump the current through the battery due to the voltage difference is 1.8 voltage [10]. The battery capacity is 500 mAh which means it can supply the current for 33 hours, but it depends on the time taken to run the motor. This 9 V battery allows to recharge up from a USB port in 22 minutes. That means the boat

can function well without any problem based on the energy supply. **Table 6** below shows the voltage, capacity, and type of battery for the motor and blades.

Table 6: Voltage, capacity, and type of battery for motor and blades

Voltage	9V
Capacity	500mAh
Type	6F22 (carbon-zinc)

4. Conclusion

From this project, we succeed in making the seabin boat prototype that can collect trash such as plastics and bottles on the surface water without consuming a lot of workforce and cost since it uses recycled items. The boat can collect 240 g load of weight with maximum speed, 0.043 m/s, and energy capacity equals 500 mAh. This boat has the potential to be used as a waste collector and can catch our public's attention to create awareness of preventing pollution around the water environment. Thus, in the future, further studies should be carried out to improve the performance of this prototype.

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