

SOLAR POWERED AQUATIC TRASHBOAT / SPAT

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CERTIFICATION

Solar Powered Aquatic Trash Boat /SPAT

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ABSTRACT

Trash is one of the biggest problems on earth. This waste can pollute and endanger the natural wildlife and environment of the lake. The Solar Powered Aquatic Trash Boat (SPAT) project is dedicated to realizing an eco-friendly, remotely operated vehicle, solar-powered trash boat concept. The remote control function allows floating trash to be picked up from the middle of the lake, which is usually unreachable by traditional trash collection methods that require the mobilization of many people to move along the lake shores. People have to go to the shore of the lake and wait for the garbage in the middle of the lake to be swept away by the lake's current. Construction of the vehicle was completed, and continued by the testing of its electrical, buoyancy, navigation, and trash collection ability. A *buoyancy* test showed that the boat floats perfectly with the weight of 11 kg. Navigational tests showed that the boat can travel at a maximum speed of 1.2 km/h and can be remotely controlled within a range of 150 meters. Electrical tests have proven that the boat can sail continuously without interruption as long as it is connected to the solar panels. In the absence of sunlight, the boat still can sail for 5 hours. For energy cost comparison, solar power is free but when using conventional home power electricity, the estimated annual electricity bill is about \$5.4 USD, or about 78,000 Indonesian rupiah. Trash collection performance tests have proven that the boat's net can collect around 1 kg of garbage in one collection round before it returns to shore for disposal.

Keyword: Vehicles, Boat, Solar Energy, Garbage, Dynamo, Lake, Alternative energy

Full documentation link: <https://www.youtube.com/@athazkaraytapjani>

FOREWORD

We express our gratitude for all god's blessings, guidance to us, so that we can successfully complete this paper. The MOSTRATEC 2023 research is titled Solar Powered Aquatic Trash Boat (SPAT).

We have compiled this MOSTRATEC 2023 research paper to the fullest extent and in the process we have received support from various parties who facilitated the preparation of this paper. For this, we express our deepest gratitude to all those who contributed to the preparation of this paper.

In addition to all this, we are fully aware that there are still many shortcomings in sentence structure and grammar. Therefore, we welcome all comments and suggestions from readers with open arms so that we can improve this document.

Finally, we hope that the MOSTRATEC 2023 paper titled **Solar Powered Aquatic Trash Boat/SPAT** can provide usefulness and inspiration to its readers.

Depok, Indonesia. 23 October 2023

Athazka Ray Tapjani

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PART I

PREFACE

1.1 Background

Lakes formed when fresh water pools together in one certain region of land due to the movement of a river or the existence of natural springs. A lake's existence is crucial because it supports a living ecosystem and serves as a significant water source for surrounding living things. In general, lakes play a significant role in human life and serve three main purposes: ecological, agricultural, and socioeconomic.

For the continuation of human existence and the life of the surrounding ecosystem, the lake serves a crucial ecological purpose. In this situation, the lake serves as a place for agriculture and contains a built-in mechanism for the reproduction of living things, such as the growth of fish. Lakes provide socioeconomic purpose by serving as gathering areas for people and as a way for people to generate economic benefit, such as through tourism. Trash that people mistakenly or purposely throw into lakes is the result of the interaction between people and the lakes.

One of the major issues facing the planet is trash. The ecosystem in the lake and marine life can be harmed by trash that pollutes the land and the oceans. In order to gather data and conduct research on the impacts of garbage, particularly plastic trash, on the ecosystem of a lake in Geneva, Switzerland, a team of scientists went on an exploration in 2016. They investigate the impact of the chemicals emitted by plastic garbage. The findings were concerning; the majority of these samples included hazardous and poisonous substances like cadmium, mercury, and lead (BBC News 2018).

This project creates tools that can move trash from the lake's surface, especially from the area that is usually unreachable by people. This device, which we refer to as SPAT (Solar Powered Aquatic Trashboat), was made to be able to roam over the surface of a lake utilizing solar energy that is stored in a battery. The dynamo, electrical, and navigation systems will all be powered by the battery. There will be no water contamination like there would be with a gasoline-powered engine because it uses solar power.

1.2 Formulation of issue

Given this context, the issue are as follows:

1. How does this vehicle collect trash around the lake?
2. Is it possible to build the idea of a solar-powered boat for transporting trash?
3. Does this boat work well to lessen the amount of trash on the lake's surface?

1.3 Aim of the research

Based on the formulation of the problem above, the following are the research objectives:

1. To realize the idea of solar-powered boats that are useful for moving trash on the lake's surface and environmentally friendly.
2. To test the idea of a trash transport boats and offer ideas that could be used on a larger scale
3. To determine how well the boat performs when transporting trash

1.4 Benefits of the research

The benefits of this research are as follows:

1. To prove the concept of a solar-powered trash collector and if it is possible to build it.
2. Boats that have been made can be an alternative solution for the community in cleaning the lake, especially for the area polluted by trash.
3. Eco-friendly solar-powered garbage collection boat can save costs for cleaning the lake. It should be proven to be more effective than the current collection method.

PART II

LITERATURE REVIEW

2.1 Trash pollution in lakes



Picture 2.1 Trash on the lake (lens.monash.edu)

As it is generally known, there is a big trash problem in the community because some people like to litter near the lake. This disturbs the balance of the lake's environment. The environment in South Sulawesi's Lake Matano, Indonesia has already been harmed by trash. The population of *butini* fish is harmed because of trash. The *butini* fish, according to some locals, are becoming harder to find. Fishers did not have to travel very far to reach the lake's middle before the early 1990s. These fish are now difficult to locate, even in the middle of the lake. Even a fishing day can result in an empty basket. (Eko Rusdianto - Mongabay)

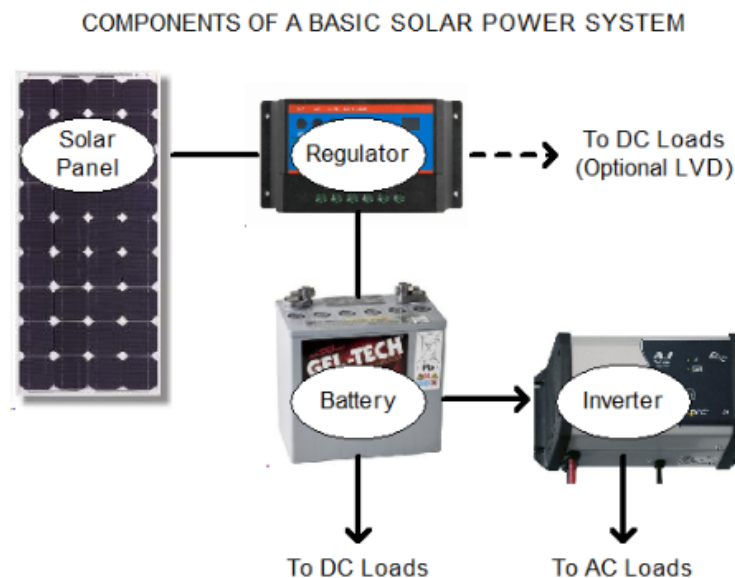
2.2 Solar power as a alternative source of energy



Picture 2.2 Solar Panel (Shutterstock.com)

Solar radiation is the light that the sun produces, also referred as electromagnetic radiation. The amount of radiation from the sun that reaches any given area on the Earth's surface changes, even though every location receives some sunshine during the course of a year. This radiation is captured by solar panels, which converts it into useful energy that we use. **(US Department of Energy)**

2.3 Solar panels as means of charging batteries



Picture 2.3 Components of a basic solar power system (Solaronline.com.au)

To charge the battery, the solar panel converts sunlight into electricity in DC current. A solar charge controller acts as regulator, that makes sure the battery is charged correctly and is not damaged, and offers the battery with this DC current. While AC appliances need an inverter to convert the DC electricity into AC power, DC appliances can be powered directly from the battery.

(Solar online australia)

PART III

RESEARCH METHOD

3.1 Research Method

This research was conducted using the **design thinking** methodology. This method was developed by Herbert A. Simon in 1969. The method consists of five phases: **empathize, define, ideate, prototype, and testing**. The author understands the problem to be solved and then analyzes the problem. After the analysis, the author develops the solution, designs and prototypes it, and finally tests it.

3.2 Research Development

A. Time and Place

In the months of January 2022 to September 2023, research and preparation of papers is done in the physics laboratory of Pribadi Bilingual School Depok (PBSD), Indonesia.

The development of the boat is done in the author's home and the boat's testing is done in Lake Cilodong, Depok, West Java, Indonesia.

B. Tools and Materials

Tools and materials needed for the making of the SPAT boat are as follow:

Tools

Pipe cutter	1 Unit
Spray paint	1 Unit
Scissor	1 Unit
PVC glue	1 Tube
Electrical Tape	1 Unit
Electric drill	1 Unit
Screwdriver (+) and (-)	1 Set
Glue gun	1 unit

Materials

2 ½ Inch PVC pipe	2 ½ inch, 4 Meters length
¾ Inch PVC pipe	60 Centimeters length
Cable Ties	1 set, nylon material
Pipe connector	8 Pcs
PVC pipe lid	8 Pcs
Solar Panel 10 WP - Polycrystalline	1 Unit
Solar Panel Controller	1 Unit
12 v used motorcycle battery	1 Unit
Remote controller FlySky i6 and receiver IASDb16	1 Unit
Dynamo Motor DC 775 type 12 v	2 Units
30 Cm propeller shaft with waterproof tubing	1 Unit
Propeller cw and ccw	1 Set
Electronic Speed Control (ESC) waterproof	1 Unit
Parallel ESC cable	1 Unit
DC to AC Inverter 180w	1 Unit
LiPo battery 3600 mah 3s 11.1 v	1 Unit
LiPo battery cable split	1 Unit
Trash net	1 Unit
Used 12v processor fan from computer	1 Unit
Waterproof action cam	1 Unit
LiPo battery Charger	1 Unit

C. Steps on assembling the SPAT Boat

1. Making the boat's hull

First steps are making the boat's hull.



Picture 3.2.1 Making the boat's hull.

1. Cut the pipe into 2 ½ inch lengths, each 60 cm long, to make 2 tubes.
2. Cut the ¾ inch pipe into 4 tubes, each 50 cm long.
3. Cut a 10 cm long piece of 2½ inch pipe eight times for the connection.
4. With a pipe cap, close each 2 ½ inch pipe with a length of 10 cm eight times.
5. Close all the ¾ inch pipe with the 10 cm pipe connector for 4 times with the pipe cap.
6. Tie the pipe with the cable ties 4 times.
7. Make a platform for the navigation and electrical system using the ¾ inch pipe, 2 times.
8. Connect the net to the square pipe and attach the waterproof action camera to the square pipe.

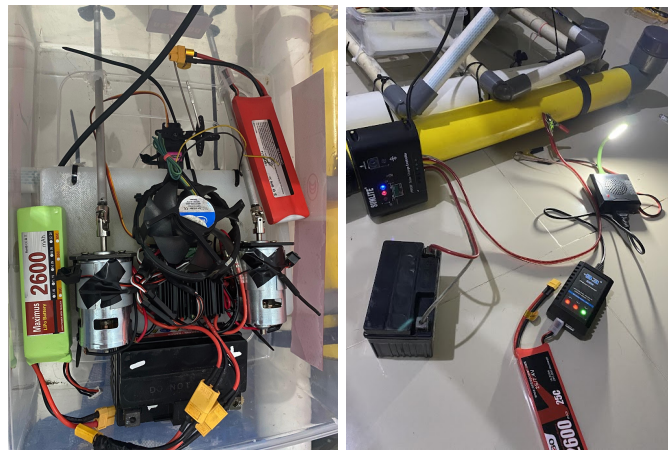
2. Making the boat's electrical system

The second stage of work on the SPAT boat is the design and assembling of the boat's electrical system. The boat is powered by two dynamo or an electric drive motor. In this case, the author uses a type 775 dynamo as the motor. The energy for the two electric dynamos was supplied by the 11.1-volt LiPo battery, which has a capacity of 3600 mAh. To charge the battery, the author uses solar panels that convert solar energy into electricity through a controller called a solar charge controller.



Picture 3.2.2 boat's electric

During the development process, the author discovered the fact that the dynamo and the ESC components generate some heat. As a solution to this high heat problem, the author added a small fan from his personal computer's processor. This fan allowed the boat to reduce the heat emitted by the ESC and dynamo, thus extending the life of the boat.



Picture 3.23 Electrical system

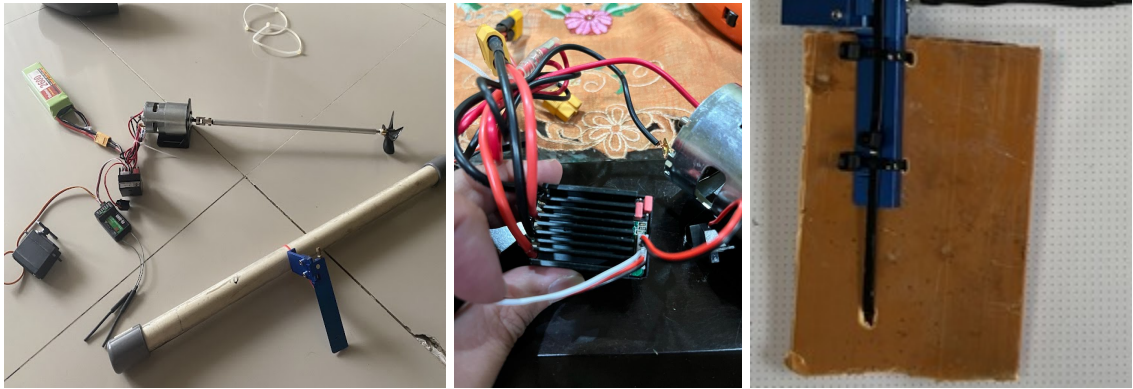


Picture 3.2.4 The solar panel system

- Place the solar panel on top of the pipe platform that has been made.
- Set the solar panel according to the needs of the Lipo battery.
- Connect the battery with the solar charge controller and connect the battery with the navigation system.

The author assembled all the electrical components in a thick-transparent plastic box. The author chose this thick plastic box because it was light and easy to open and close. At each connection between the box and the boat's platform, the author ensured that droplets would not penetrate as the boat moved over the water. The author secured each of these connections with a glue gun. This SPAT boat is proven to be waterproof.

2. Making boat's navigation module



Picture 3.2.5 Navigation system

- Attach the modified rudder at the back of the boat.
- Attach the aluminum bar from the servo motor in the control box.
- Attach the servo control cable from the servo to the receiver IASDB.
- Attach the propeller to the dynamo using the 30 cm rudder shaft.

To allow the author see objects in front of the SPAT boat, the author installed an action camera in front of the SPAT boat. to connect with the smartphone.

3.3 Designing, Prototyping and Testing

The first test is the electrical system. This test is done to prove that the energy supply from the solar panel was stored in the used motorcycle battery and fed to the LiPo battery. The LiPo battery powers the dynamo system and the servo motors that control the navigation system.

The second test tests the boat's buoyancy, the ability to float without sinking. This is to ensure that the boat does not sink even when lifting heavy loads. The total weight of this SPAT boat is 11 kg. The largest components contributing to the boat's weight are the solar panels, batteries and the two motor dynamos.

The third test tests the navigation system. This test was conducted by the author to confirm that the SPAT boat could be controlled remotely with the FlySky FS-i6 remote control. This navigation system test also tested the ability of the action cam, which allowed the author to see objects in front of the SPAT boat.

The fourth test tests the boat's ability to collect garbage. This test is done by collecting floating garbage in the lake and weighing the collected garbage.

After the four tests have been successfully performed and accomplished according to the author's criteria, the author enters the data processing phase. Data processing is performed to find the overall performance of the project in collecting trash

CHAPTER IV

PROJECT RESULT

4.1 SPAT Boat final result

During the construction of the SPAT boat, the author conducted 4 tests including electrical testing, buoyancy testing, navigation system testing and trash collecting testing.

A. Electrical system test results

The author tested the boat's electrical system. This test is an initial test to verify the functionality of all components. The author then looked for data to support the conclusion that the electrical test was successful. The data found are battery life without solar power, electricity running costs, and the energy required to power the boat.



Picture 4.1.1 Testing electrical system after battery is fully charged

All electrical tests run smoothly. It is proven that the SPAT boat works as long as it is connected to the solar panel. The boat can run for around 5 hours when it is not connected to the solar panel. Note that the power input produced by solar panels is highly dependent on the sunlight. When it's sunny, the boat can charge the battery with the solar panel. By using a multimeter, the author conducted several tests. The author measures the result of the conversion from solar power into electrical power. The value is in Volt, as follow:

Result of conversion	Time and weather	Average Voltages (V)
	Morning - sunny	18.912
	Noon - sunny	21.70
	Afternoon - cloudy	17.21
	Evening	0.92

The author also measured the voltage value of the electrical system. The following are the finding:

	Voltage(V)
Solar charge controller to used motorcycle battery	12V
Used motorcycle battery to AC-DC Controller	12V converted into 220V
AC-DC Converter to LiPo battery charger	220V
LiPo battery charger to LiPo battery	12V

The author also measured the electrical current flowing from the LiPo battery into both of the dynamo motors. The author discovered that the voltage value correlates with the speed of the dynamo motors that will move the boat. Below are the voltage comparison:

Rotation	Voltage(V)
Remote Control rudder - Half	6V
Remote Control rudder - Full	12V

According to the collected data voltages, the author can calculate the time required to fully charge the used motorcycle battery with the specification of 12 V with capacity of 3.5 Ah, as follow:

- a. Average estimated efficiency of a solar panel is 20%
- b. Converted power provided by a 10 WP calculated as follow:

$$10W * 0.2 \text{ (efficiency 20\%)} = 2W$$
- c. The author can calculate the battery charging current as follow:
 Electrical charging current (A-Ampere) = available power (W) / Battery Current

$$\text{Electrical current charging (A)} = 2W/12V = 0.17 \text{ A}$$
- d. With the above charging current calculation, the author can calculate the time required to fully charge the battery.
 Charging time = battery capacity (Ah) / Electrical charging current (A)

$$\text{Charging time (hour)} = 3.5 \text{ Ah} / 0.17A = 20.6 \text{ hours}$$

From the above data, the author discovered that the boat needed 20.6 hours to fully charge the used motorcycle battery of 12 V with a 3.5Ah battery.

Electrical power that accumulated in the used motorcycle battery can be used to fully charge the LiPo 3200 mAh 11.1 V. The author conduct calculation on how long it takes to fully charge the LiPo battery:

- Battery specification : LiPo Battery 11.1V 3600 mAh
- Battery charger specification: Input volt: 100-240V AC with output current of 1.6A
- To calculate the time of charging: $3.6 \text{ Ah} / 1.6\text{A} = 2.25 \text{ hour}$

As additional information, the author also calculated how many times the used motorcycle battery can fully charge the LiPo battery. The calculation as follow:

Amount of charging = capacity of motorcycle battery (Ah) / LiPo battery capacity (Ah)

Amount of charging = $3.5\text{Ah} / 3.6\text{Ah} = \underline{0.97 \text{ times of charging}}$

The power consumption of the two 775 12V motor dynamos is about 22W, and the total with other components is 29.64W. The charging rate of the 3600 mAh battery is 1 A. The Author calculates the electrical consumption by multiplying 11 V with the speed of the charging process of 1A. The electrical consumption is 11 watt. The author tried to operate the boat without connecting it to solar panels. A fully charged LiPO battery allows the boat to run for 5 hours without interruption.

To determine the cost of power consumption, the author calculated the boat's power consumption using the formula : power consumption (watts) x (hours) / 1000. After determining the electricity consumption, the author compared it with Indonesian electricity prices. That is an average price of Rp. 1,450 per kWh.

Boat's electric consumption	Period	Electric consumption (kWh)	Price (Rupiah)
	1 Hour	0.03	42.98
	1 Day	0.15	214,89
	1 Month	4.51	6,536.24
	1 Year	54,09	78,434.85

Table 4.1.1 Electric consumption and price

The table above shows the costs needed when charging LiPO batteries with electricity provided by PLN, Indonesian Power Services provider. If the SPAT boat is connected to the solar system, there is no cost in Rupiah or USD. As an additional information, it takes 4 hours to fully charge the battery in sunny weather using the solar panel.

The author also conducts a cost effectiveness comparison if the boat is powered with a set of disposable batteries. To match the capacity of a 3s 3600mAh 11.1V LiPo battery with AA batteries, the calculation as follow:

- a. Convert the capacity of the lithium-ion battery from milliampere-hours (mAh) to ampere-hours (Ah): $3600\text{mAh} \div 1000 = 3.6\text{Ah}$
- b. Calculate the total energy in watt-hours (Wh) for the lithium-ion battery:
 $3.6\text{Ah (capacity)} \times 11.1\text{V (voltage)} = 39.96 \text{ Wh}$
- c. Determine the capacity of a single AA battery. Typical alkaline AA batteries have a capacity of around 2000-3000mAh. The author assumed 2500mAh for this calculation.
- d. Calculate the number of AA batteries needed to match the capacity of the lithium-ion battery: $39.96\text{Wh (lithium-ion battery capacity)} \div (2500\text{mAh} \div 1000) \text{ (capacity of a single AA battery in Ah)} = 15.98 \text{ AA batteries}$

Rounded up, the author would need approximately 16 AA batteries connected in series to match the capacity of the 3s 3600 mAh 11.1V LiPo battery.

	LiPo Battery	AA Batteries
Amount required	1 Unit	16 Units
Rechargeable	Yes	No
Weight	250 Grams	420 Grams
Cost	325,000 Rupiah / 21,2 USD One time upfront purchase	180,000 Rupiah / 11,7 USD Multiple time purchase

The use of single-use and disposable AA batteries is not environmentally friendly. Disposable batteries contain so many harmful materials. AA batteries typically contain a mixture of toxic heavy metals including mercury, lithium, zinc and nickel that can cause severe damage to the gastrointestinal tract due to their corrosive nature, with mercury oxide batteries most likely to degrade and fragment.

Moreover, there is a risk of the boat being unable to return back to the user if the AA batteries run out when the boat is in the middle of the lake.

B. Buoyancy test results



Picture 4.1.2 buoyancy testing

The author conducted experiments on the SPAT boat, specifically on the placement of electrical components on the hull. The author were able to find the optimal layout and balance of the boat. This optimal layout allows the boat to stably lift a total load of 11 kg.

This test proves that the buoyancy contained in the boat is sufficient to support the 11 kg of cargo and 1 kg of waste successfully transported from the middle of the lake. Optimal placement also protects the SPAT boat's control box from water leakage into the box.

C. Navigation test results



Picture 4.1.3 Navigation testing

This navigation test includes testing boat speed, boat navigation, and the maximum distance between the remote control and boat. The author did a speed test. For reference, Distance(s) is the length of the path traveled by the object. The speed is formulated by the formula $s = v \cdot t$, where (v) is velocity and (t) is travel time. Common units used in Indonesia are meters and kilometers. According to the Kamus Besar Bahasa Indonesia (1997), time or duration is the entire sequence of moments in which a process, action, or condition exists or occurs. A timescale is the interval or duration of an event between two states or events.

These measurements show that it takes 90 seconds for the boat with solar panels to travel 30 meters in a straight line, compared to 65 seconds when not connected to the solar panels. This is caused by an additional load on the installed solar panels.

Table 4.1.2 speed calculation table

No	Energy components in boat	Distance (Meter)	Time (Second)	Speed (KM/H)
1	SPAT Boat with solar panel	30	90	1,2 km/hour
2	SPAT boat without solar panel	30	65	1,6 km/hour

Good results were also obtained in sailing tests. This is indicated by the smoothness of the boat when it turns 360 degrees and moves forward. SPAT boats can be controlled within the range of 150m. The SPAT boat's remote controller gives an audible and numeric warning, the value "Err1:%" increases as the distance between the remote control and the boat increases.



Picture 4.1.4 Change in error when distance is increasing

4.2 Trash collecting ability test

This test successfully proved the ability to collect garbage. From the middle of a distant lake that cannot be reached by humans, it can collect 1 kg of garbage and return it to the lakeshore for landfill disposal.



Picture 4.1.5 Trash collected in the net

CHAPTER V

CONCLUSION AND FURTHER DEVELOPMENT

5.1 Conclusion

The aim of this research is to realize the concept of a solar-powered boat which is environmentally friendly and useful for transporting trash that is floating, especially in areas that are unreachable to people. The test continues with testing electrical, buoyancy, navigation and trash collecting performance. The author are able to discover that this boat can transport the waste it can collect. Buoyancy test results show that the boat can float perfectly without sinking with 11 kg plus 1 kg of waste collected in the middle of the lake. Navigation tests have shown that the two dynamos can move the boat and the rudder can effectively change the direction. Electrical test results show that this SPAT boat can operate independently as long as it is connected to the solar panel system and has relatively low running costs when not connected to the solar panel system. The boat can collect trash with a maximum capacity of 1kg. Data collection also shows that the boat could travel at speeds of up to 1.2 km/h, proving effective in collecting waste. This project can be developed into a larger scale.

It is hoped that the ability of the successfully built SPAT boat will help the community better clean up the lake. This is because, in the past, communities had to mobilize large numbers of people to walk along the edge of the lake and wait for the garbage floating in the middle of the lake to be carried to the edge by water currents.

5.2 Further development

With the proven concept of the SPAT boat, the author saw the possibility of developing other functions. Among others are:

1) Development of waste storage capacity

In the first version of the SPAT boat, the author set up fishing nets to collect garbage. It is noted that this fishing net has a small storage capacity, when the net is full, the SPAT boat has to return to the lakeshore garbage disposal starting point. The author saw the possibility of attaching a conveyor system and mini trash containers to the hull to automatically pick up trash.

2) Development in terms of navigation

In the first version of the SPAT boat, the author used remote controls and action cameras to navigate the boat. The author believes that navigation functions controlled by Arduino boards and the global positioning system "GPS" may be added in the future. The initial concept was for the author to map the location of the lake and use GPS to determine the coordinates of where the SPAT boat would pass. Based on GPS coordinate data, an Arduino board controls the electrical and navigation systems, allowing the SPAT boat to patrol and transport trash along points on its route. The concept is based on early research that was conducted by an open source project called Open Boat Projects.

BIBLIOGRAPHY

Eko Rusdianto. (2019) DANAU-DANAU INI HADAPI MASALAH SAMPAH SAMPAI IKAN ENDEMIK MAKIN LANGKA

Available (online):

<https://www.mongabay.co.id/2019/05/20/danau-danau-ini-hadapi-masalah-sampah-sampai-ikan-endemik-makin-langka/>

BBC. (2018) SEBERAPA BESAR ANCAMAN BAHAYA PLASTIK DI DANAU DAN SUNGAI

Available (online): <https://www.bbc.com/indonesia/vert-fut-44035755>

UNIVERSITAS UMY. (2021) APA DAN BAGAIMANA SISTEM KERJA PANEL SURYA

Available (online): <https://elektro.umy.ac.id/apa-dan-bagaimana-sistem-kerja-panel-surya/>

THECITYFOUNDRY. (2021) DYNAMO: PENGERTIAN, FUNGSI, KOMPONEN, JENIS, PRINSIP KERJA

Available (online): <https://thecityfoundry.com/dinamo/>

ZULHAJ ISMAIL NASARUDDIN. (2019) PERANCANGAN PERAHU LISTRIK BERTENAGA SURYA

Available online: https://digilibadmin.unismuh.ac.id/upload/6139-Full_Text.pdf

FAHRUL ISLAM. (2020) PERANCANGAN PEMBANGKIT LISTRIK TENAGA SURYA PADA PERAHU NELAYAN

Available (online): <http://repository.unhas.ac.id/id/eprint/1612/>

SHANTY MANULLANG. (2021) ANALISIS POTENSIAL PEMANFAATAN ENERGI SURYA PADA KAPAL IKAN DI PANTAI SELATAN PULAU JAWA SEBAGAI SUMBER ENERGI

Available (online):

http://repository.unsada.ac.id/2085/1/34238_Jurnal%20Riset%20kapal%20Perikanan_shnaty%20Manullang.pdf

Litovitz T, Schmitz BF Ingestion of cylindrical and button batteries: an analysis of 2382 cases. Pediatrics 1992;89:747–57)

DOCUMENTATION



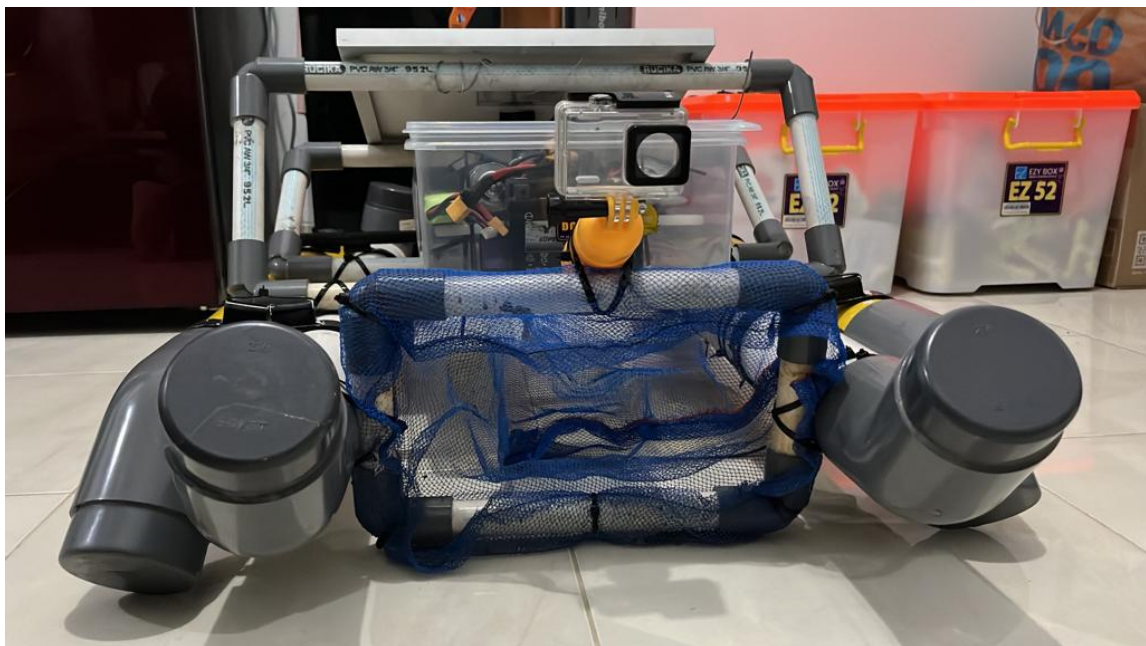
Author, when assembling the SPAT Boat's hull



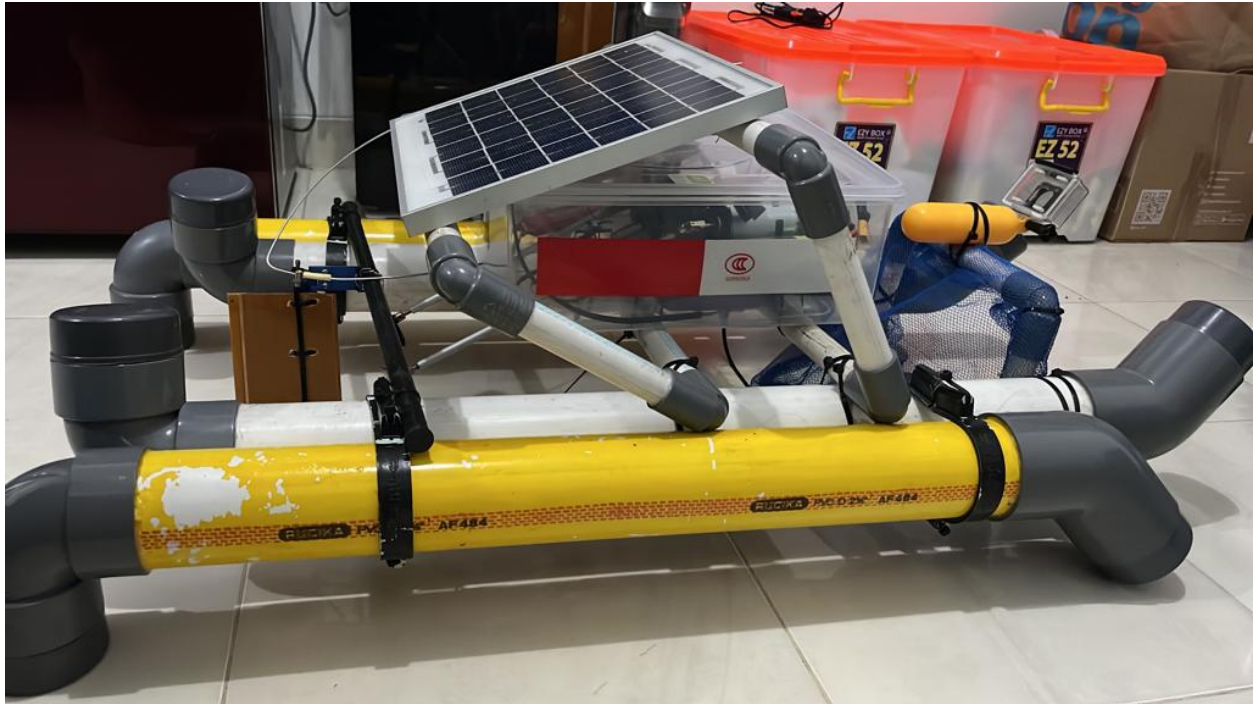
Early prototype of the SPAT Boat



Author, when assembling the dynamo motor on the SPAT Boat's hull



Front side of the SPAT Boat



Side view of SPAT Boat



Top view of SPAT Boat



SPAT Boat when doing its initial *buoyancy* test
Link youtube video : <https://youtu.be/dN7RCXB38mY>



SPAT Boat when doing its maiden journey to clean up the trash in lake
Link youtube video : <https://youtu.be/OPPvSUhVPXg>



SPAT Boat when doing its maiden journey to clean up the trash in lake

Link youtube video : <https://youtu.be/rKCZVJpNfN4>