ICONSS Proceeding Series
The 2nd International Conference on Natural & Social Sciences (ICONSS 2019)
Palopo, 13 – 14 September 2019

Design and Manufacturing of a Water Bike to Pick Up Garbage on Matano Lake

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Abstract

Garbage is one of the main factors that greatly affects and causes a decrease in environmental quality, especially waste in the water area. Matano Lake in Soroako experienced this condition. The garbage in Matano consists of plastic, cans, cloth and some types of daily activities waste of peoples surround the lake that can pollute the cleanliness and health of lake water. Matano Lake is the water source used by residents of Soroako for processing drinking water, cooking, bath, wash, and other household needs. The shape of the banks of the matano lake varies, in the form of slopes, swamps, and steep cliffs, so that some sides can't be cleaned from the land. Based on these conditions, research is needed to facilitate the cleaning of lakes from waste. Research in the form of design of bicycles that can float and move above the water surface, and has a component to pick up and accommodate garbage from the lake. Stages of research consist of data collection, analysis, design, manufacture, and testing. The design phase includes calculation of construction safety, selection of standard components, drawing of construction and components details to be made. Tool manufacturing phase through metal machining and fabrication processes. Testing phase includes testing of buoyancy ability, motion speed, and load ability. The main components consist of transmission elements, frames, buoys, drive systems, movement direction control, hooks, and trash cans.

Keywords: *water bicycle, garbage, environmental cleanliness*

1. Background

Garbage is one of the main factors that greatly influence and causes a decrease the environment quality, especially waste in water areas. Waste is defined as objects or items of building / human excrement, animals or plants or which originate from human life activities that can cause contamination of water, soil, and air so as to cause damage to the human environment (Rizal, 2011). Matano lake in Sorowako village, Nuha district, experienced this condition. Garbage in Matano Lake consists of plastic, cans, cloth and several kinds of used goods from the daily activities of the surrounding population that can pollute the cleanliness and health of the lake's water. Matano Lake is the water source used by Sorowako residents for drinking, cooking, bathing, washing and other household needs. Garbage which is disposed of carelessly will have an impact on health such as diarrhea, cholera, typhus, dengue fever and so on (Wahyuni, 2015). The shape of the shores of Lake Matano varies, in the form of gently sloping beaches, swamps, and steep cliffs, some areas can't be cleaned up from the edge of land. Based on these conditions, research is needed to design and manufacturing of tools that used to facilitate the cleaning of lakes from the garbage.

https://doi.org/10.30605/iconss.94

Figure 1. Garbage at the bottom and surface of Matano Lake Sorowako.

2. Method

This research was carried out in Matano Lake Sorowako, Nuha Subdistrict, East Luwu Regency. The product is made at the Akademi Teknik Sorowako (ATS) campus. the data collection methodology used in this research is a literature study, observation, interview, and documentation. Observations were made directly on the shores of Matano Lake and interviews with residents who inhabit the area. Observations generate ideas and alternative tools to collect the garbage on the lake consider the area condition. The waste is in area of 10 meters from the edge of the lake and the water depth of ± 1-2m. The resident's problems who want to do the cleaning is difficult to reach garbage that sinks at the bottom of the lake and rubbish on the surface of the water with a steep lake edge. Based on these conditions an alternative tool in the form of a water bicycle was chosen to facilitate the cleaning of the lake from rubbish at the bottom and its surface. The stages of the research include the stages of data collection, design, manufacture, and function testing of the water bicycle.

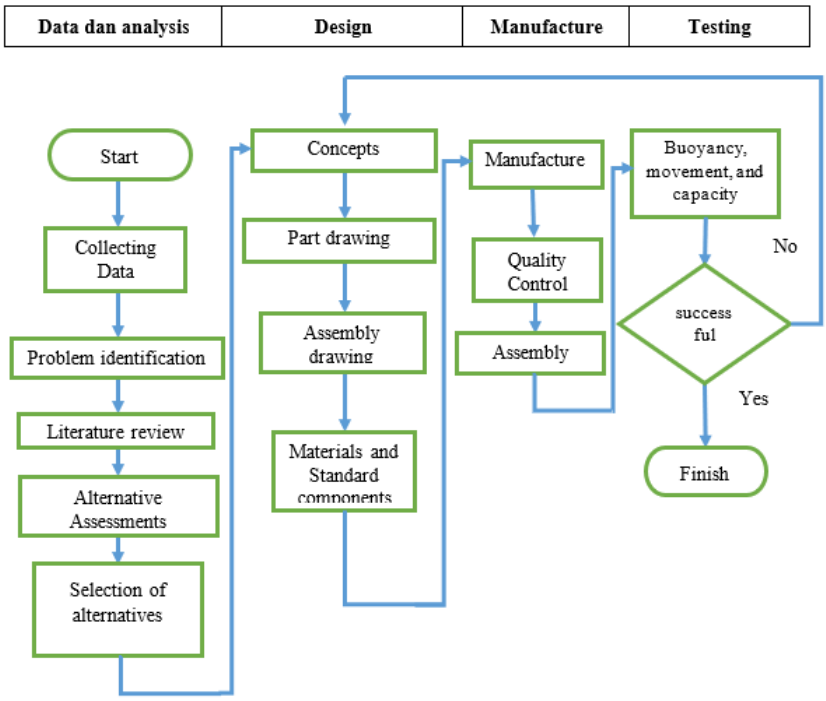


Figure 2. Flowchart of research stages

The literature study generates references and lists the main components of water bikes. The main components of water bikes for the needs of garbage transporters are the frame, transmission system, drive media, buoys, steering fins, hooks, and garbage receptacles. The technical aspects assessed from alternatives are manufacturing, assembly, operation,

maintenance, material, ergonomics and safety construction factors for the user. The manufacturing process is carried out in the laboratory and workshop of the Akademi Teknik Soroako. Production stages of the machine components in accordance with those specified of the design. The type and size of materials, standard components, and driving components are chosen based on consideration of design demands, the safety of machine construction, ease of manufacture, material availability, and facilities for processing materials into machine components. Material selection also considers the strength of the material fracture (Mitchell, 2004). The expected rotation ratio is 1: 6. To get the output rotation, the chain and sprocket connections connected to the bevel gear need to be planned. The rotation ratio is determined by the following equation (Sonawan, 2010):

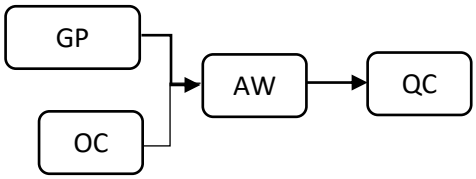
$$i_{Sprocet} = \frac{Z1}{Z2} = \frac{48}{16} = 3$$

$$i_{Chain} = \frac{Z3}{Z4} = \frac{36}{18} = 2$$

The gear used is a type of bevel gear. The gear classification is selected according to the water bikes construction is bevel gears with a shaft intersecting based on the shaft position (Sularso & Suga, 2004). The process of making each component of the product goes through several stages of work. Machine components are made by using several types of workshop machine tools (Daryanto, 2002). The manufacture process consists of MRK = Marking (MRK), TU = Turning, AMP = Sandpaper, GP = Cutting Grinder, MI = Milling, BW = Bench work, BO = Drill, QC = Quality control, AW = Arc welding, SH = Shearing, MO = Molding, HS = Hack saw as in table 1.

Table 1. Product manufacturing process selection

Components	**Manufacturing process**
Frame	MRK → GP → BO → AW → QC
buoy tube	MAR → HS → Mal → MO → AMP
Steering	MRK → SH → HS → BO → QC
Propeller shaft	GP → TU → MI → QC
Bevel Gear	OC → TU → MI → BW → QC
Transmission mounting shaft	GP → TU → MI → QC
Pipe clamp	MRK → SH → BO → QC

Components	Manufacturing process
Garbage Bin	
Garbage hooks and net	

Buoyancy is caused by fluid pressure (Cengel & Cimbala, 2006). Buoyancy is influenced by the ratio of the total load of the bicycle components, passengers and the garbage compared to the compressive force of the fluid. The condition for a floating object is if the object weight is smaller than the force of fluid pressure. Mass of the object consist of Bike mass = 75 kg, Operator= 65 kg, garbage = 17 kg.

Total mass (M_{total}) = M_{bike} + $M_{max\ operator}$ + $M_{garbage}$

= 69 Kg + 112 Kg + 17 Kg = 198 Kg.

F_{total} = ρ_{water} x g x V

M_{tot} x g = ρ_{water} x g x V

198 x 10 = 1000 x 10 x V

1980 = 10000 V

V = 0.198 m^3

The volume of the buoy tube based on the volume of water transferred is 0.198 m^3 or equal to 198000cm^3

Volume 2 *buoys*

= π x r^2 x l x 2

= π x $12{,}7^2$ x 230 x 2

= 232.967 cm^3

Comparison of the water volume with the volume of 2 buoys tube is 198000 cm^3 : 232967 cm^3 = 0,85

The volume of the buoy tubes that floats above the water surface is 0.15 part of the total buoy for the maximum load.

3. Results & Discussion

This section contains the findings of the research and the discussion of the research findings. The results section may contain charts, figures or tables.

The water bicycle design is shown in Figure 3. The dimensions of the tool are designed for one person. The main parts of a water bike for garbage transport are:

1. Bicycle frame
2. The transmission system, using chain-sprocket combination, shaft and bevel gear. Chain functions are to transfer the rotation generated from the pedal and sprocket to the shaft. Bevel gear serves to continue the rotation generated from the sprocket to the shaft and propeller.

3. Motion guide device is a propeller to determines the forward or backward movements
4. Buoy tubes from PVC Pipe, serves to produce the buoyancy of the water bicycle.
5. Steering fins are made by aluminum plate as a steering direction of the bicycle to the right or left motion that is connected to the steering handle barr.
6. Fork-shaped hooks to take garbage at the bottom of the lake and nets to pick up garbage that floats on the surface of the water
7. Square garbage bin to maximize the volume of the bin.

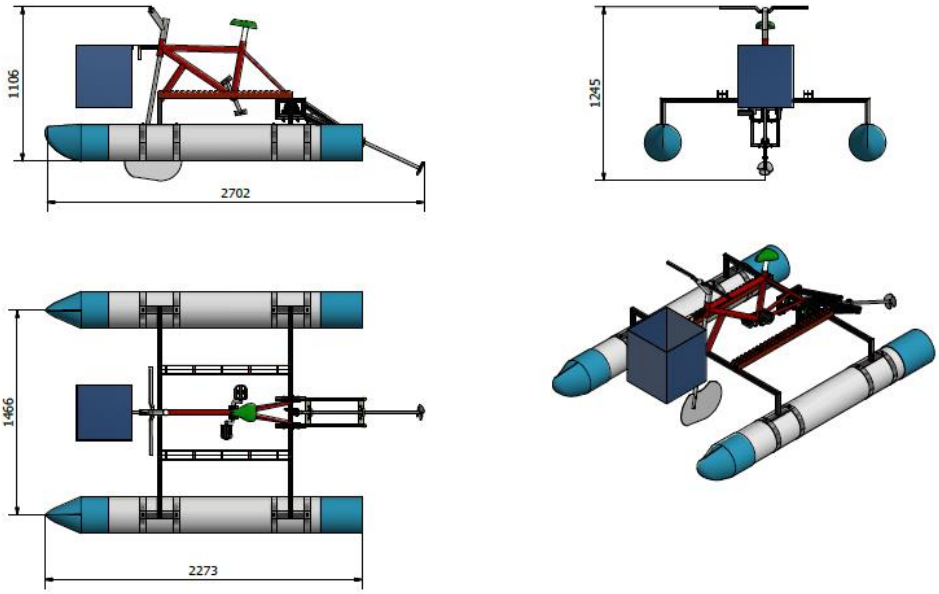


Figure 3. The water bicycle design

Water bicycle testing was carried out at Lake Matano, Sorowako. Testing consists of:

1. Buoyancy testing
2. Bicycle movements testing in the water
3. Capacity testing of garbage bin

Buoyancy testing of bicycles in water is carried out with a variety of loads. The first test of buoyancy with a bicycle load without the operator and garbage. Next test with additional operators with variations in operator weight. Measurement of the depth of the submerged buoy tube was carried out in three positions, the front side, middle and backside of the buoy tube. The measurement accuracy is affected by water waves. In table 2 and figure 4 show the test results. The backside of the buoy is deeper in sinking size than the middle and front sides. The average depth of the buoy that sank without operator and garbage was 10.17 cm whereas when given an additional load of 17kg of garbage and the operator was 112kg The average in it was 20.83cm with the pipe diameter of 25.4cm.

Table 2. Testing of bicycle buoyancy in water

No	Load description	Mass	Sank depth of buoy tube (cm)			
			Front	Middle	Back	Average
1	Bike	69 Kg	9	9.5	12	10.17
2	Bike + Garbage (17 Kg)	86 Kg	11	10	12	11.00

No	Load description	Mass	Sank depth of buoy tube (cm)			
			Front	Middle	Back	Average
3	Bike + Operator 1 (50 Kg)	119 Kg	9	15	19	14.33
4	Bike + Operator 2 (65 Kg)	134 Kg	11	16.5	20	15.83
5	Bike + Operator 1 (50 Kg) + Sampah (17 Kg)	136 Kg	12	16	18	15.33
6	Bike + Operator 2 (65 Kg) + Garbage (17 Kg)	151 Kg	13	17	19	16.33
7	Bike + Operator 3 (112 Kg) + Garbage (17 Kg)	198 Kg	20.5	20	22	20.83

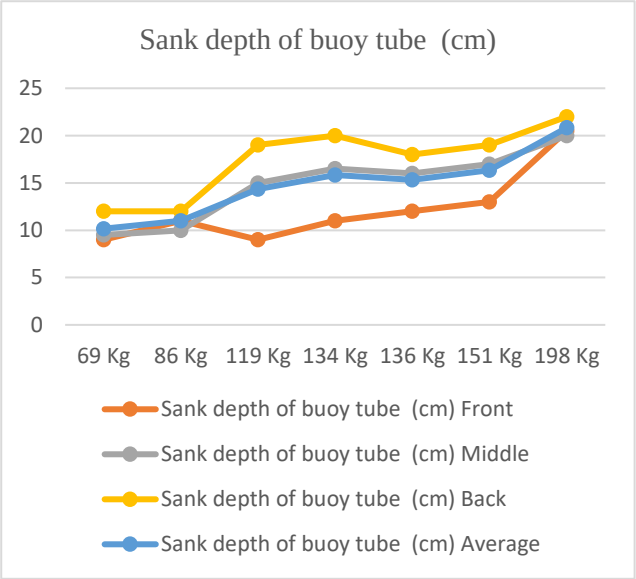


Figure 4. Graphic testing of bicycle buoyancy in water

Bike movement and garbage transport testing are shown in figure 5. The movement test of the bicycle in the water is carried out to test the ability of the bicycle to move forward and backward straight, and also the movement to turn right and left while moving forward or backward. The test results show that all the movements were reached. the Collection and garbage transport were also successful. garbage collection at the bottom of the lake was successfully carried out with a fork-shaped hook. Garbage collection on the surface of the lake was successfully carried out using a net. The weight of wet garbage that corresponds to the volume of the garbage bin of 72000 cm^3 is 17 kg.

Figure 5. Bike movement and garbage transport testing

4. Conclusion

The design and products of water bikes have been successfully made with the main parts consisting of a bicycle frame, transmission system, drive media, buoys, steering fins, hooks, garbage bin. The results of buoyancy testing of bicycles in water are set at less than 198 kg consisting of the weight of the bicycle unit, garbage, and operator. Loading more than 198 kg causes the float to sink. Bike movement and collecting garbage testing is also succeeded. The results of the water bicycle movement test showed that all types of bicycle movement were achieved. the ability to move in the direction of forwarding and backward straight, and the movement to turn right and left while moving forward or backward. Collection and transporting of the garbage were also successful. Garbage collection at the bottom of the lake and above the water surface was successfully carried out with hooks and nets. The weight of wet waste obtained from the test data is 17 kg.

Acknowledgement

This research was supported by Akademi Teknik Soroako and the students, especially Asri, Nusul Taufiq Hidayat, Abraham Yermianto. Thanks for their support and facilities in making process of this research product.

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