Journal of Physics: Conference Series

PAPER • OPEN ACCESS

DEVELOPMENT OF RIVER TRASH COLLECTOR SYSTEM

To cite this article: M.F. Mukhtar *et al* 2020 *J. Phys.: Conf. Ser.* **1529** 042029

DEVELOPMENT OF RIVER TRASH COLLECTOR SYSTEM

M.F. Mukhtar[1,2], M.I.F. Rosley[1], A.M.H.S. Lubis[1], N. Tamaldin[3], M.S.F. Hussin[1], A.A.M. Damanhuri[1], , K.A. Azlan[1], N.H. Hanizat[1]

[1]Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[2]Advanced Manufacturing Centre, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[3]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

fariduddin@utem.edu.my

Abstract. Protecting environment from various sources of pollution is imperative to ensure the sustainability of the earth. Water pollution has also become one of the significant issues due to increasing water-related activities such as transportation, fisheries, entertainment and many others. It threatens the well-being and prosperity of human and nature as well as the quality of water in the surrounding. This project of River Trash Collector System (RTCS) is to develop a system that can remove floating trash, oil, fuel, and detergents from the water to resolve water pollution problem so that would not threaten Malacca River the as one of the main tourist attraction to Malacca and it is marine life. The threats faced by marine life and surrounding particularly in the Malacca River may appear to be overpowering. The design is based on Solidwork design platform and using Rapid Prototyping to fabricate prototype scale model of a physical part or assembly using three-dimensional computer-aided design (CAD) system. At the end of this research, a fully functional trash collector is expected to be operating along the shoreline of Malacca River to clean up debris. This developed RTCS will further benefit especially for Malacca River in resolving the water pollution issues.

Keywords: Buoy, Water pollution, Trash Collector.

1.0 INTRODUCTION

Water pollution continues to become a threat to economic activities along the river increases. It has been estimated that there are over 5 trillion pieces of plastic floating in the world's oceans and rivers not include 10,000 times more in the deep sea [1]. As the economic growth of the countries increased, many activities contribute to the water pollution either coincidentally or intentionally from risky dumping of waste. Notwithstanding contamination, environmental change, and other overwhelming issues, marine life face extinction.

To reach the objective of protecting the water quality, water pollution control strategy must be from watershed administration point of view and in light of the comprehend of financial support, hydrology, geology and water states of watershed and on the entire water environment control and administration through taking complete measures [2]. Other than that, compost spill over from homesteads and yards is an enormous issue for Malacca River [3].

The additional supplements cause eutrophication and thriving of algae blossoms that broken down oxygen and suffocate other marine life [4]. For example, solid garbage also makes its way to the Malacca River. Plastic sacks, inflatables, glass bottles, shoes, bundling material make the sea polluted. Plastic refuse, which breaks down gradually, is regularly mixed up for sustenance by marine lives. High convergences of plastic material, especially plastic sacks, have been discovered hindering the breathing sections and stomachs of numerous marine species. Because of the water pollution, the River Trash Collector System (RTCS) needs to be designed in order to reduce water pollution.

RTCS is designed and developed in order to reduce pollution in the area. The general idea comes from Seabin concept which acts as a trash collector in the sea. The Seabin is a floating rubbish bin that is located in the water at marinas, docks, yacht clubs and commercial ports. The Seabin moves up and down with the range of tide collecting all floating rubbish. Water is sucked in from the surface and passes through a catch bag inside the Seabin and then pumped back into the marina leaving litter and debris trapped in the catch bag to be disposed of properly. The Seabin also has the potential to collect a percentage of oils and pollutants floating on the water surface. However, several improvements are necessary for the RTCS aligned with green technology initiative as promoted by the State of Malacca.

2.0 CONCEPTUAL AND DESIGN PHASE

2.1 Research Framework

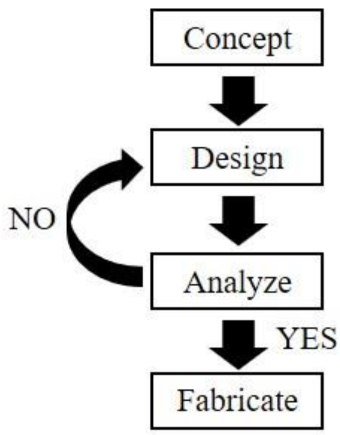


Figure 1. Research Framework

In order to meet the objectives of the study, a research strategy as in Figure 1 has been developed. It contains four stages starts from identifying problems of water pollution at Malacca River. An observer study was done to identify types of debris. Trash that floated along the river consists of plastic/foam cup, cigarette butt, and others part of small trash as shown in Figure 2.

Figure 2. Trash Collected

Currently, a cleaning boat was used to sweep off this trash. This cleaning boat as in Figure 3 has a gap with a net in front to trap the floating trash. This procedure just needs one watercraft driver and another collector. The collector gathers the huge waste into the receptacle to anticipate blockage. The garbage will be gathered once per day, and every procedure just takes around 3 hours for the entire river. RTCS will make simplify this process.

Figure 3. Cleaning Boat

Therefore, RTCS was developed to collect trash automatic and systematically without leaving any debris behind. As shown in Figure 4, Seabin concept was used where water will flow in then streams out through the base of the container and up into the pump on the dock. The water then moves through the pump where there has the choice of introducing an oil or water separator and clean water then streams once again into the sea.

Figure 4. Seabin Concept

From this Seabin project, several improvements consisting its cost and functions had been done. Originally it was made from aluminum while new design will be made from various elements such as wood and plastics to reduce cost. Another improvement was that new design can move freely along the river since water in Malacca River will be flush twice a week to clean the river. If it stays firmed on a pole like Seabin, it will damage the pump inside it.

2.2 Conceptual Ideas : Ballast Tank

For the floating mechanism, RTCS will utilize the concept of the ballast tank. It has a compartment beneath the main body that use to hold water which then provides stability for the vessel. By using this concept, it is easier for RTCS to sink at the accurate level on the water level instead of using stone or iron ballast. After all, ballast tank also allows water to be pumped out temporarily when entering a shallow water condition. Figure 5 shows how was ballast will be working inside RTCS.

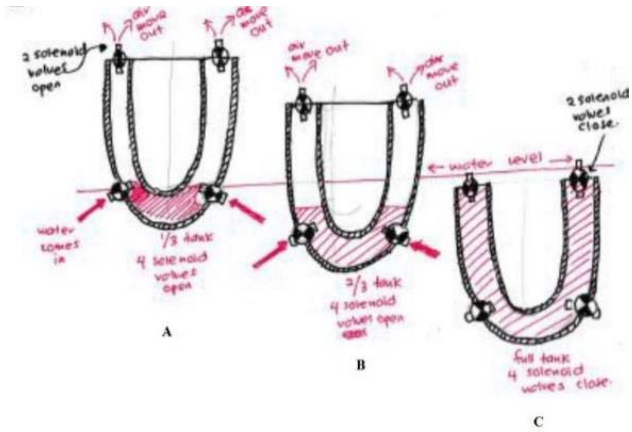
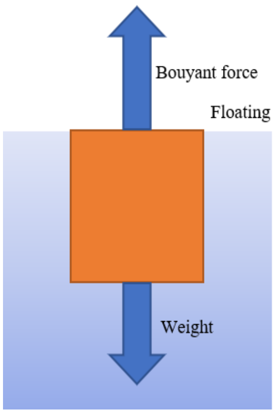


Figure 5. Ballast Tank of RTCS

There will be three stages for a ballast tank to be working, starting from A to C. For the first A and B step, four solenoid valves that had been placed on top and below the vessel will be opened. This was to allow water to come in and replace air which will then moves out towards the other two valves. After all, air had been pulled out, and RTCS has been on par with the water level, all four solenoid valves will be closed once it was fully submerged as in C. To maintain on par with the water level. The concept of buoyancy will take part in the floating mechanism [5]. Since we want RTCS to float on a level with water the force exerted must equal with water buoyancy force. The situation of buoyancy force described in Figure 6.



$$F_w = F_b$$

$$F_w = m_0 g$$
$$F_b = \rho_w g V$$

$F_b = F_{bouyancy}$
$F_w = F_{weight}$
$\rho_w = water\ density$
$g = gravity$
$m_0 = mass\ of\ object$
$V = volume\ body\ full\ submerged$

Figure 6. Buoyancy Force

3.0 ANALYSIS AND DISCUSSION

3.1 Analysis of Weight and Materials

Table I shows the weight calculation of RTCS. Since it consists of many parts, it is crucial to determine each part weight. This is important since we need to find the suitable diameter of the vessel that obeys (1).

Table 1. Weight Analysis

No	Item	Material	Weight
1	Submersible water pump	Metal	10kg
2	Overall vessel body	PVC	4kg
3	Lower layer	Wood	15kg
4	Upper Layer	Arcylic	0.5kg
5	Other Components	ABS	0.5kg
		Total	30kg

3.2 Buoyancy Force Analysis

The force immersed inside water must be equal than buoyancy force exerted onto the body. We consider the load that can be submerged in water about 42 kg equally to 205.93 N. This load was only the expected trash that will be collected inside the main layer. With RTCS weight was about 30 kg, we can determine the minimum diameter of the main layer. The calculation described as in equation (1), (2), and (3).

$$F_W = m_0 g = (42 + 30)(9.81) = 706.32 \quad (1)$$

$$F_b = p_w g V = p_w g(\pi r^2 h) = (1000)(9.81)\left(\pi^2(1)\right) \quad (2)$$

$$\begin{gathered} F_W = F_b \\ 706.32 = 30819.02 r^2 \\ r = 0.1514 \end{gathered} \quad (3)$$

The height of RTCS was set as 1 meter as the depth of Malacca River was around 2 meters. There were two vessels; inner and outer vessel. By using formula, the diameter of the vessel discovered to be 32 cm as the inner vessel radius was set to be big enough so that the trash can flows inside the vessel.

3.3 Design of RTCS

For the design phase, four initial in-water designs were done and only two were selected after concept screening method. These two designs were then undergone concept scoring method to make the decision for fabrication as suggested by [6]. Result obtained were in Table 2.

Table 2. Concept Scoring Method

		Design Concept			
		Design I		Design J	
Selection Criteria	**Weight Score**	**Rating**	**Weight Score**	**Rating**	**Weight Score**
Ease of handling	25 %	3	0.75	3	0.75
Ease of use	20 %	3	0.60	2	0.40
Ease of manufacture	15 %	2	0.30	2	0.30
Durability	25 %	3	0.75	3	0.75
Attractive design	15 %	3	0.45	2	0.30
	Total Score	2.85		2.50	
	Rank	**1**		2	
	Continue?	**Yes**		No	

For the design I, RTCS will consist of two layers, the outer layer act as ballast tank while inner layer will be the trash collector tank. On the outer layer will have two solenoid valves for the ballast for the water to flows in. A pack of sand inserted between outer and inner vessel that will help RTCS to sink.

For inner vessel, it consists of a submersible electric water pump which power source is generated by 12V water generator inside the buoy hanging on to the side of RTCS. A bag inserted into the inner vessel to trap trash that inserted from the water. The water pump processed dirty water and clean water will exit from the hanging buoy. RTCS use a green source which is a self-water 12V generator and its systematic design as in Figure 7.

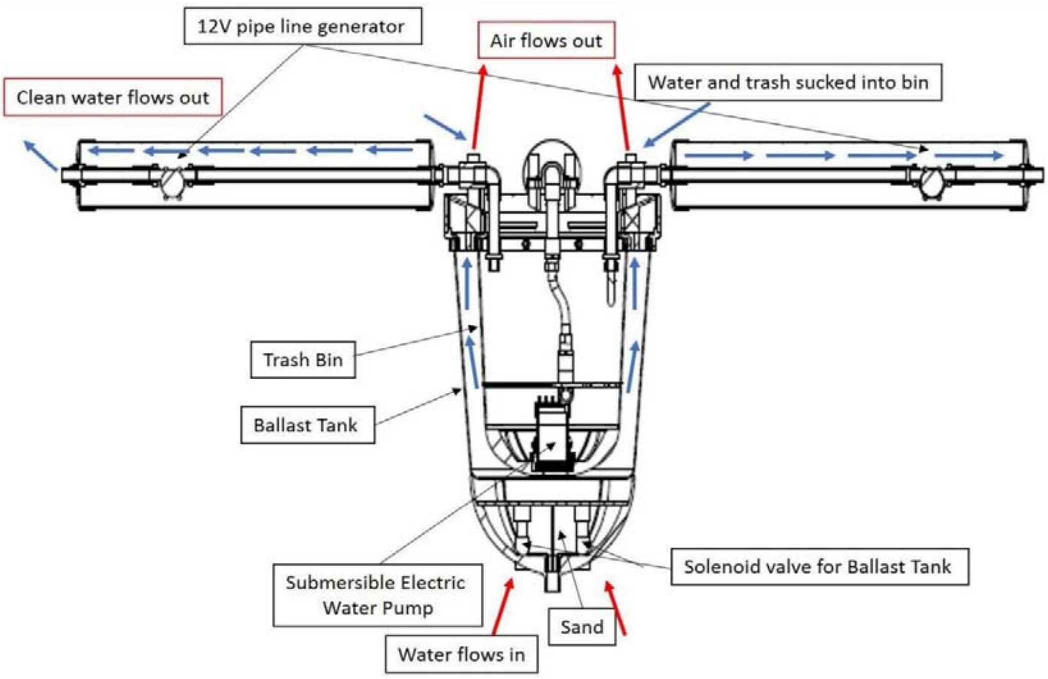


Figure 7. RTCS Design

Figure 8 shows how trash and water will flow inside RTCS. Since the water and RTCS will be leveled, nearby floating trash was sucked, by applying the concept of half vacuum water suction. Oily water will also flow down with the trash but then trapped by the film bag attached inside the inner vessel. It was then filtered and processed so that only the remaining clean water flows back into the river.

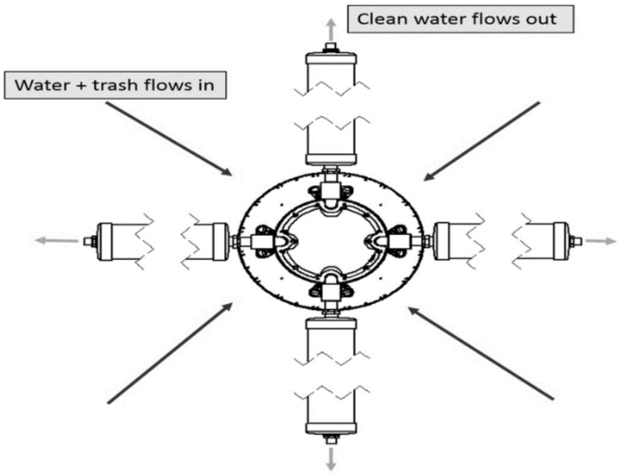
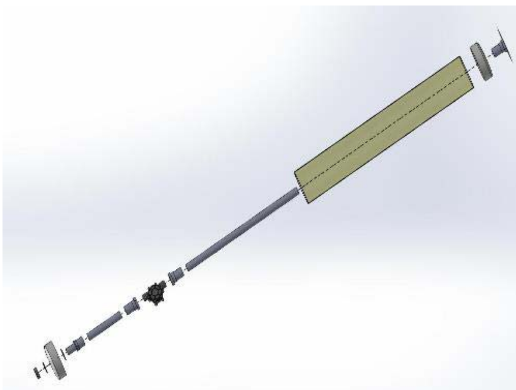


Figure 8. Water orientation of RTCS

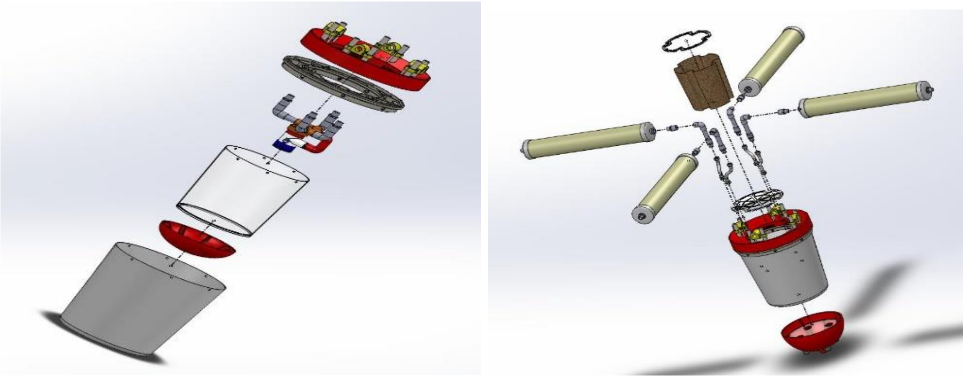
A submersible electric water pump placed at the bottom part of the inner and outer vessel. It helps RTCS to sucked water inside the vessel, where water will then be cleaned and pumped back into the river through four buoys allocated above RTCS as in Figure 9 which then rotating the 12V generator to produce power source for the suction pump.



n Design

Figure 9. Buoy Design with a 12V generator

Figure 10(a) and (b) shows the assembly of all parts of RTCS component which is the inner vessel and overall body of RTCS respectively. While Figure 11 shows the isometric view of RTCS on how RTCS will look like at the end of its development.



(a) (b)

Figure 10. (a) : Inner Vessel Component and (b): Assembly of RTCS

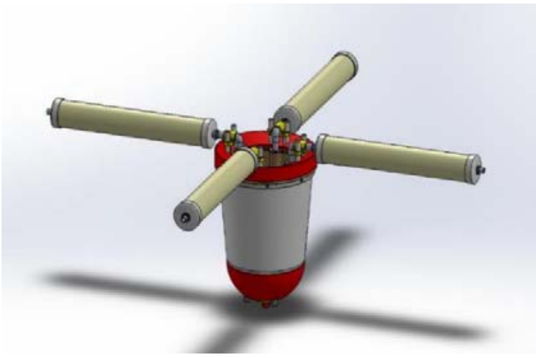


Figure 11. Isometric view of RTCS

4.0 ANALYSIS AND DISCUSSION

Various machines were used for RTCS production. Waterjet cutting machine used to cut acrylic for the plate on top of the inner vessel. As the other component used 3D Printing with ABS material. However, it was time-consuming to print out all the component. Figure 12 shows the inner system fabrication and assembly according to the desired drawing.

For body production of the inner and outer vessel, two plastic bins were used according to their shape. RTCS use existing element as for cost reduction. The top and bottom of the bin were manually cut as they will be fit into RTCS as shown in Figure 13. While Figure 14 shows the complete prototype of RTCS. It follows 90% of the desired drawing diagram with regards to its material and size. Total cost production of RTCS was bearable since the only cost for the printing components. Other than that, it just uses the recycled material.

Figure 12. Inner System Fabrication

Figure 13. Inner and Outer Vessel

Figure 14. Prototype of RTCS

However, several improvements can be done. The body of RTCS is advisable to use fiber instead of plastic material since it is stronger and harder. The idea of having buoy is good but the placement of them should be considered since it may disturb the route of the trash that flows. The water pump might also be replaced with a stronger suction pump since the suggested pump may not be able to works in continuous condition with the weak suction.

ACKNOWLEDGMENTS

The author would like to thank Universiti Teknikal Malaysia Melaka for funding this project through Applied Oriented Research grant (AORG) no PJP/2017/FTK-AMC/S01562.

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