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Abstract. The objective of this paper is to study, analyse and investigate the main contributor of plastic pollution which has become the world major infamous problem nowadays, and to explain our platform design which aim to help in reducing the issue of floating trash. Annually, more than 2 million tonnes of plastics have been tossed to water body and eventually washed away to the sea. Not just living marine organisms become targets and carrier of harmful viruses but some of marine animals suffer a direct mortality after plastic ingestion. Numerous negative impacts of plastic pollution to the environment and the society had been identified. This study shall include the methodology; classification of trash cleaning systems as well as the efforts to tackle this problem. Static and dynamic systems have been categorized to distinguish their effectiveness. As for this paper, the proposed design will be focusing on dynamic system which is fully autonomous. It is a multi-functional design which incorporated with different types of sensors. This paper also emphasizes the novelty and uniqueness of the proposed design as compared to existing ones; in terms of architecture and its functionality.

1. Introduction

Pollution can be characterized as an expansion of substances to the encompassing condition [1]. The substances could be categorized as good and bad and it can be determined in three states of matter; either in the form of solid, liquid and gas. These three major forms of substances may carry damage to condition particularly to environments and to human as well. The most common pollutions known are air, land and water pollution. Aside from these infamous pollutions, there are different kinds of pollutants including noise pollution, light pollution and plastic pollution. As can be alluded to reference [1], it is said that any sorts of pollutions consistently have negative effects on the surrounding environment; to wildlife and frequently human wellbeing and prosperity. In reference to [1], the pollution may also be caused by natural events. The events could be occurring due to forest fire and active volcanoes. These two natural events may create all the three pollutions, to air, water and land pollution. Not to mention by human as well, the pollution may occurred as a result of human activities such as deforestation and coal mining which consistently lead to land and air pollution.

Above all those pollutions, plastics pollution has been become the greatest threat ever faced by the world nowadays. According to reference [2], plastics were initially being used in the year of 1284. It was in England by Horners Company. They used tortoiseshells for natural plastic production. As mentioned in [3], the term tortoiseshells was invented in 1601 and it can be addressed to as “thermoplastic” or “natural plastic” due to its properties. Dated back in 1600 BCE, a ritualistic

"ballgame" was used by the Pre-Columbian Civilizations in Mesoamerica. The ballgame was made from natural rubbers; cast from horns and shells. Authors from reference [2] stated the rubber was then improved with an addition of sulfur and became vulcanized rubber by Charles Goodyear in 1839. A similar research has been studied by a German physicist which later turning the vulcanized rubber into successful and helpful materials. On the same year, Polystyrene (PS) was also invented by the German scientist which is mostly used for protection in packaging for nowadays used. Thirty-three years after that, Polyvinyl Chloride (PVC) was discovered by Eugen Baumann. The PVC was then fully commercialised and become well-known in United States in 1920s and due to its advantageous, the PVC can act as flame retardant. In reference to [4], figure 1 shows the graph of countries which has contributed to the plastic pollution to the ocean.

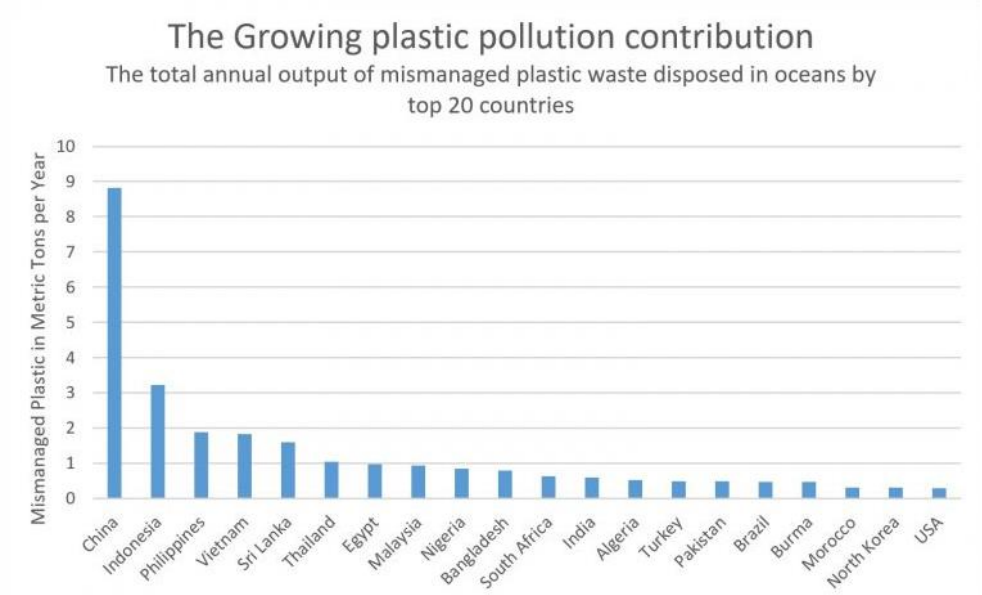

Figure 1. Contribution of Plastic Pollution

2. Literature review

As stated earlier in the introduction of this study, the most common type of pollutions can be categorised into three; Land pollution, Water pollution and Air pollution. These pollutions have become the major factor that caused destructions to the surrounding environment which mainly created by human activities. Apart from this, the pollution may also occurred by natural causes.

According to [5], the pollutions always concentrated in the metropolitan cities and suburban areas due to large number of population resided in the area. On the other hand, the rapid growth of industrialization at that time had caused the pollution becoming a universal problem.

Pollution has been always an issue in China [6]. The most common problem is water pollution. A recent study had shown that over half of the river sections in remoted areas in China are rated as hazardous for human contact. In reference to [7], there are several risk valuations been made. One of the risk valuation is as illustrated through pollution case in Guangxi province of China. The problem was caused after an enormous dump of garbage. This happened in September 2016 where a quarter size of a whole shipment loaded with household garbage was dumped into the river. However, this situation was captured and noticed by nearby villagers. After some reports made, an instant action had been made by the local department of environmental protection by launching an emergency water quality monitoring of the river. The Guangxi Environmental monitoring centre had also conducted a thorough investigation through the monitoring data after identification of water damage in the river.

Another case study was taken from reference [8], where synthetic material such as the disposal of plastic has been seen as a threat to the surrounding and its widespread throughout the environment has

caused the destruction of Anthropocene; an act of human activities which has an influence on the environmental impact hence the future of the earth system.

A recent study has been conducted according to [8] that in 2010, there was an estimation between 4.8 and 12.7 million tonnes of land-based plastic which was not properly managed and mishandled had been insinuated to the oceans. Due to this case scenario, it has been noted that the plastic pollution had delivered an obvious unfavourable effects on the organisms, ecosystems, human health and socioeconomic factors including aquaculture, tourism and navigation.

The latest evaluation made from reference [8], at least 5 trillion plastic debris was recorded drifting on the surface of the ocean. This Marine Plastic Pollution (MPP) had been extended to five subtropical ocean gyres as well as the Arctic Ocean; accumulation at the convergence zones. The accumulation of large scales of marine plastic was the result of aftereffect of the wind flow, the currents of the ocean as well as the thermohaline circulation. Thermohaline circulation can be defined as a flow of heat fluxes and freshwater across the sea surface and the interior mixture of heat and salt [9]. Apart from this convergence zones, there is comparable concentration in the subtropical gyres. It has been recorded that this was the result of the heavily populated areas in the Mediterranean Sea, South China Sea, Gulf of Mexico and Bay of Bengal.

As indicated by [8], the biological pathway of living marine organism that had ingested the marine plastic cannot be reversed and stopped as it has a noteworthy impact in the worldwide dispersion of plastic particles. Factually demonstrated that this plastic served as an effective substrate for sessile species; Tube Worms, Bivalve Mollusks and Barnicales just as for motile life forms. Apart from that, it additionally affirmed that plastic could host very harmful viruses, microbial communities and bloom species which also known as "Plastisphere". Beside this, the marine plastic could act as a vector to transport the alien species which is invasive [8]. Regardless of the little size of the plastic, every particle has the ability to convey living organisms and to re-disseminate destructive substances which may alter ecosystem composition and its functionality as well as changing their genetic diversity.

The plastic has become rapidly in use since the end of Second World War due to its durability as well as its lower cost of production [10]. Since then, plastic has been on production and currently its production exceeds 280 million tonnes per annum. Based on the same reference, it is believe that estuaries are the main source of transporting the plastic to ocean and of course due to other factors such as industrial outlets and recreational fishing activities. There has been a research made in South Africa that the marine debris is the source of foods by seabirds in the mid of 1980s.

From the reference [11], the plastic pollution has been greatly produced and the source of input to the marine environment have drastically increased. The reference is also once again express that the marine debris such as plastics are being ingested by the marine animals resulting in direct mortality and range of sub-lethal effects such as laceration and gastrointestinal blockage. Estimated over 260 species of animals have been reported to have ingested the plastic debris [11].

Studies from [12] stated that the Marine Plastic Pollution (MVP) composed of macro and micro-plastic was considered severe as the authorities have limited resources and services on the island of Caribbean and Atlantic Ocean. Beside tourism, fisheries and shipping are another contributing factors of plastic marine debris. Reference [12] has identified that Henderson Island as the most severely polluted in the world.

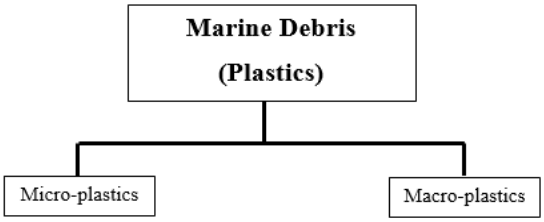

Figure 2. Classification of marine debris (plastics).

According to reference [12], the severe plastic pollution on the Henderson Island was the result of direct influenced by marine current systems of the South Pacific Ocean. As the superficial ocean currents and wind keep on blowing to this island, most of floating plastics drifted for a long-distances to Henderson Island, overtime more plastics were accumulated.

On the islands of Atlantic Ocean; the Atlantic Ocean basin proper and the Caribbean Sea, the micro-plastics were categorised into different types; most probable source and its type of material; fragments, fishing materials, single use items, non-disposal user objects and Styrofoam and foamed plastic [12].

Reference [12] suggests that the marine-based source of the debris was macro-plastic debris in island of Atlantic Ocean. Mostly found was mainly derelict fishing gear. Some researchers have studied the plastic pollution in the Falklands found at least 40 types and 38 out of 40 types of plastics were mostly sighted on the beaches used by on board fishing vessels around the island. In addition to this, over 27 types of plastics insinuated to be directly thrown into the sea [12].

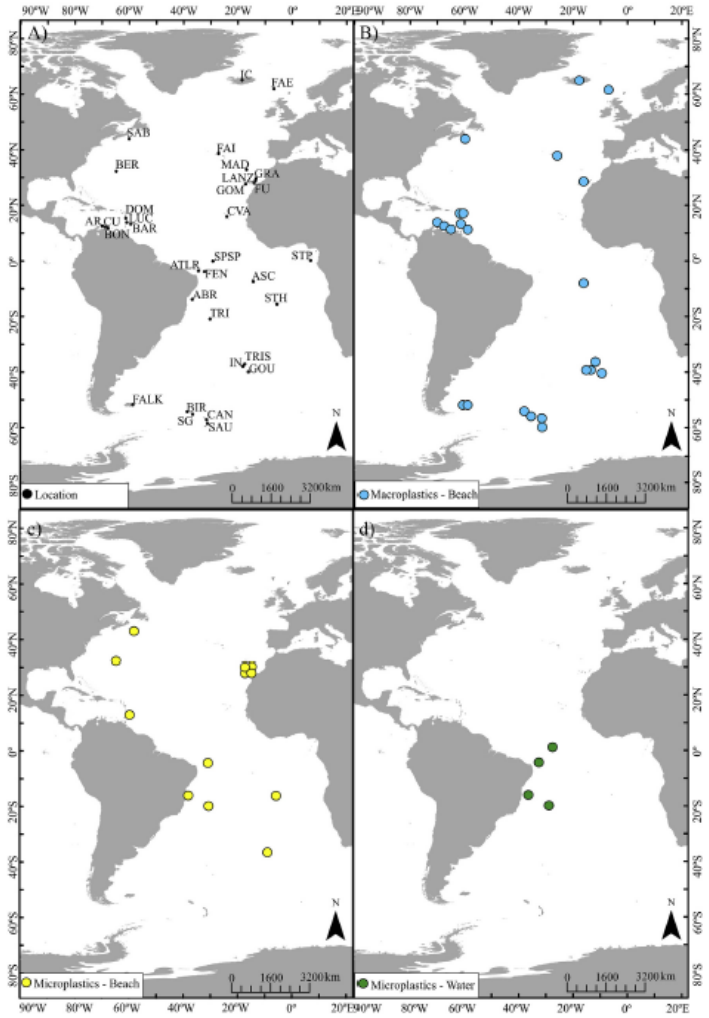

Figure 3. Location of macro and micro-plastic on the islands of Caribbean sea and Atlantic ocean.

Marine plastic pollution has been known to be a serious environmental problem nowadays. In reference to [8], this pollution was considered as hazardous as it can clearly be seen after the effect range and obvious impacts on the marine wildlife. Reference [13], described a high profile topic in recent years is the “Great Pacific Garbage Patch” where plastics are accumulated in the ocean’s world as well as in the north Atlantic Sub-tropical gyre. According to reference [13], it was estimated around

79,000 tonnes of plastics were found on the sea water surface. Based on the two studies made on the same reference, the size of the plastics had increased four times since 2014. It had been said that, there is also distinct increased in the mass of the plastic; the sea water is getting denser with floating plastics and debris but there is no indication of extending the surface area.

The second to be considered as the largest of garbage dumping area is Garbage Island which was discovered in the Gulf of Thailand. In the recent years, it [14] has been stated that this floating garbage island was spotted near the Bang Saphan district in Prachuap Khiri Khan. In addition to this [15], it was statistically estimated about 2.66 million tonnes of plastics had been tossed into rivers annually and majority of them came from Asian countries such as China, Myanmar and Indonesia.

In reference [16], Port of London Authority (PLA) introduced "drifted service" for the past several years. The service helps to collect an estimated around 250 tonnes of debris and rubbish annually in tidal Thames. Statistically recorded in 2011 and 2012, there were 248 tonnes and 239 tonnes were discarded from the river respectively. The rubbish was collected by using the fyke nets for the trials. Further trials were conducted by using different fyke nets in the river Thames. According to [16], amongst the rubbish collected includes sanitary products such as plastic backing strips, used condoms and wide range of plastic wastes. As stated in [16], there was a total of 8490 rubbish collected and counted during the trial fishing programmes

While in the District of Columbia, there was over 300 tonnes of trash found on the waterways especially along the Anacostia and Potomac Rivers. As stated in reference [17, 18], the trash will appeared and noticeable whenever there is heavy rainfall resulting from floating trash washed in from the stormwater run-off and sewer overflow.

Reference [19] stated that, a similar situation occurred in Yangtze River, China. The trash started to accumulate and increases in quantity after the Three Gorges Dam was completed in 2003. The trash initially spotted on the upstream of the Wanzhou area and starts to piling up. Variety of the trash can be found such as crop debris, construction waste, plastics and garbage. Due to this problem, the river transportation became inaccessible.

Plastic pollution is inevitable. It can happen everywhere. Malaysia is also one of the Asian country that suffers from plastic pollution. In reference [20, 21], there is many types of floating debris found in the Klang River such as plastic bottles, woods and trash. While in Bangkok, Thailand [22], the debris can be seen during the high tides. The debris composes of plastic bottles, foams and other types of trash. Even during the rainy season, there would be huge amount of aquatic weeds found in the Chao Phraya River. The reference also stated that the debris would wash down to Samut Prakan province from Sappasamit Canal.

Not just in Malaysia and Thailand, Philippine has also experienced plastic pollution. Reference from [23] stated that the most common trash found in Manila Bay is plastic bags. Based on the reference, there was about 23.2 percent of plastic bags were collected out of 1594 litters of garbage at the area. Other types of trash can also be spotted such as cigarette butts, sponges and clothes.

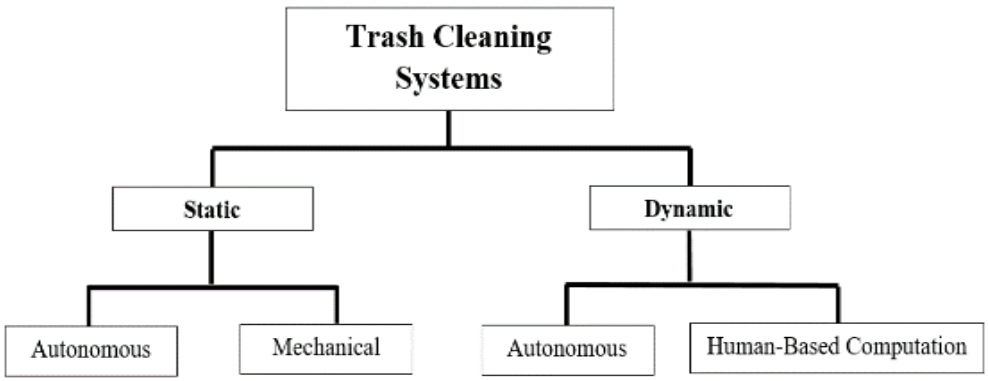

Figure 4. Classification of trash cleaning systems.

3. Efforts to tackle the problems

There are efforts currently being executed by several countries in order to reduce and overcome this plastic pollution. There are also several methods introduced to tackle this problem. Some are using mechanical and partial robotics. And some of them are integrated systems. Figure 4 above is the classification of trash cleaning systems.

Table 1. Example of static and dynamic systems.

Trash Cleaning System		
Method	**Region**	**Description**
Static - Autonomous		
Automatic trash removal system	India	It is powered by solar. The trash are collected by conveyor and the test field taken for testing were the canals and local water bodies [25].
Static - Mechanical		
Solar-powered water wheel	United State	It is powered by harnessing the energy from river current. Variety of trash were collected using conveyor and it took place in Baltimore's inner harbour [26, 27].
Dynamic - Autonomous		
Ocean clean-up project	Great Pacific Garbage Patch	It is floating barriers with 600 meters in length. It moves towards the pacific garbage with the help of natural current system and ocean's gyres [28].
Waste shark	Netherlands	It is a small aquatic drone used to collect floating trash near the Rotterdam port by patrolling around the river without oversight of human [29].
SeaVax	United Kingdom	It is a robotic vessel used to patrol the trash in the sea over a long distance. A remote command is used to guide towards the known gyre of plastic and then collected [30].
Automatic trash collection boat	China	An initiative to collect different kinds of trash including plastics, debris and construction waste [19].
Dynamic – Human-based Computation		
Buddy catamaran	United Kingdom	It is designed for cleaning marine debris as well as waterways maintenance especially marinas and harbours [31].
Trash skimmers	New York	It is a skimmer boat used for cleaning trash on both fresh and salty water surface with a low profile configuration for under lower obstruction. Able to retrieve both large and small objects by using the front conveyor [32].
Floating trash skimmer	India	It is a skimmer boat used for collecting trash and aquatic weed [33].
TrashCat	Malaysia	This skimmer boat is used to remove the floating trash and debris along the Klang River [20, 21].
Harvester	Thailand	A skimmer boat used to drag up waste mainly composed of aqua weeds and other types of debris along the Chao Phraya River [22].
Skimmer boat	Philippines	The boat is semi-mechanized and it scoop up the garbage from the water surface at Manila Bay [34, 35].
Trash robot	Chicago	It was designed with two functions; autonomous and human-based computation. It can also be controlled by using web browsing with camera installed enabling users to know their directions [36].
Ro-boat	India	It is a cleaning robot purposely created for Yamuna and Ganga River. This robot is capable of detecting pollutant such as metals, plastics and water chemical as well as ability to completely submerge under water to collect trash on the river bed [37].

There are several types of trash cleaning systems available nowadays. They can be categorised into two; static and dynamic systems. According to reference [24], static system can be defined as a state that does not move or stationary while on the other hand, dynamic system is a state that can move in all directions. Table 1 above is several examples of static and dynamic for the trash cleaning systems.

4. Proposed design

Several designs and projects have been conducted throughout the world on handling the plastic pollution. It ranges from autonomous, mechanical and human-based computation designs. All the designs were created in the hope of reducing the plastic pollution especially those plastics found on the water surface; water body and ocean.

After several research and observations made, we have subsequently developed an idea and led to produce another proposed design. The design itself can be illustrated in figure 5. Like other designs and projects, the proposed design shown in figure 5 and 6 is a result after numerous number of discussions and considerations. It was chosen due to its novelty in terms of functions and aesthetic design. It is also a fully autonomous robot vessel which was designed to collect different kinds and sizes of floating plastics and other types of marine plants on the surface of water.

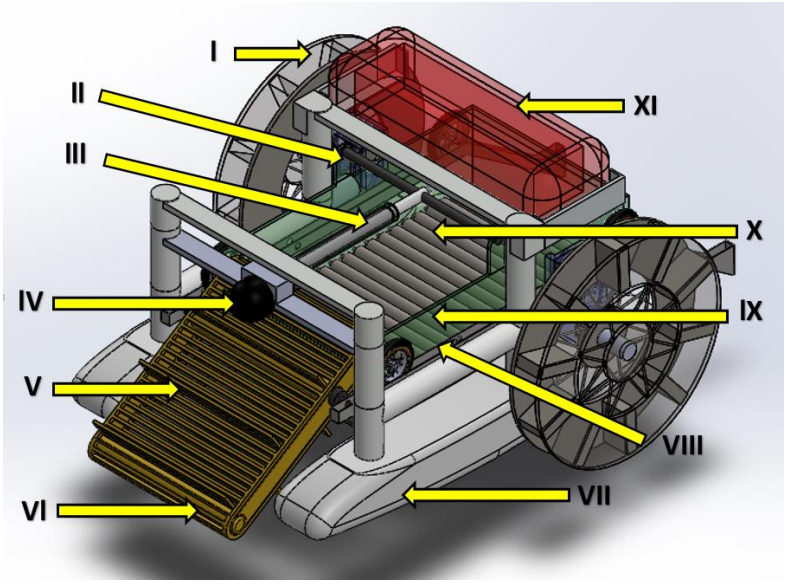

Figure 5. Overview of proposed robot trash collector design.

Apart from collecting rubbish, this robotic is also equipped with sufficient multiple sensors all around the upper frame. Among the uses of the sensors include to activate and deactivate the conveyor in the presence of the rubbish, to avoid or to dodge any obstacles that might hit the robotic vessel, to turn to any directions as well as to check the pH and quality of the water. Table 2 is a tabulated detail in function of proposed design.

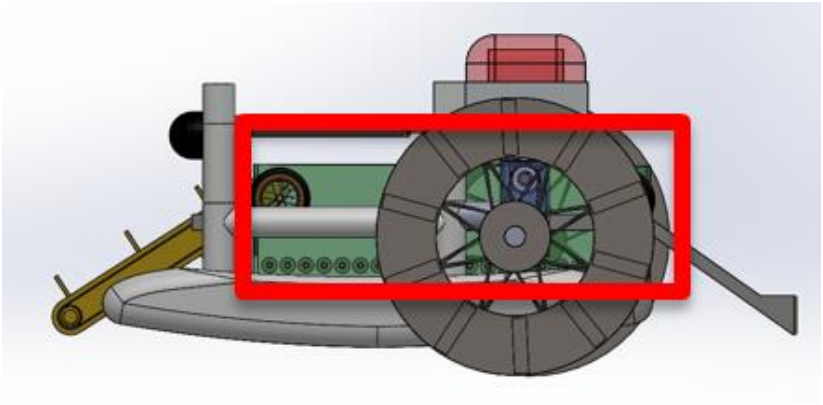

Figure 6. Side view of proposed robot trash collector design.

Table 2. Parts and functions of proposed design.

No	Part(s)	Function(s)
I	Wheel	Each wheel will be driven by a single DC motor with high torque. Both wheels are used to maneuver the directions.
II	Motor	It is a 24V DC motor with 2600 rpm. Sufficient enough to move the robotic vessel. It is a water proof motor.
III	Actuator	It is a 12V linear actuator. This actuator will be used to push the storage backward once it is fully loaded with rubbish.
IV	Sensor	It will be equipped with image sensor. Once the rubbish is detected by the image sensor, the conveyor will be activated and the rubbish will be picked up by the metallic arm.
V	Metallic arm (Hooker)	This metallic arm is used to hook a huge and heavy rubbish such as plastic bottles.
VI	Conveyor belt	The conveyor belt is used to pick-up and transfer the collected rubbish to the storage.
VII	Surf board	The surf board acts as a floating platform for the robotic vessel. The surface area and the thickness of the surf board are sufficient enough to accommodate up to 50-70 kilograms.
VIII	Run way platform	The designated run ways are used to ease the movement of storage when it is pushed backward by the actuator.
IX	Storage	The storage is used to keep the collected rubbish.
X	Rolling cylinder	Once the rubbish is collected and stored in the storage, all the cylinders will be activated and rolled to make sure the rubbish occupies the empty spaces as well as to level the rubbish at the same height. The rolling cylinder is driven by a single 12V DC motor. It is a water proof motor.
XI	Compartment	All the electrical components will be kept here and it is a water proof compartment.

The size of this robotic is 7 feet long and 5 feet in width. It has huge space enough for storing the rubbish as can be seen in figure 6. Once the sensor has detected the storage is fully loaded with rubbish, it will return to the starting point and the storage will be pushed backward by actuator using designated run ways. The provided compartment on the upper frame is used to keep the electrical components such as micro-controller and batteries. Another privilege of this robotic, it has been architecture to withstand fresh and salty water.

5. Future improvements

In terms of material wise, carbon fibre is recommended as compared to galvanized iron and mild steel for manufacturing of the frame. Beside this, the frame will be lighter and easier to be assembled and disassembled. Foldable solar panels can be equipped for the means of emergency purposes. Rechargeable spare batteries can be used to supply the power while the drained batteries are recharging. The use of Raspberry Pi as micro-controller is more desirable for artificial intelligence purposes. Global Positioning System (GPS) can be adopted for this proposed design as it can be used to locate the exact position of the rubbish. It is favourable to use remote controller with camera installed on the robot for the ease of directions.

6. Conclusion

The aim of the study was to investigate the main contributor to plastic pollution. It was found that the main sources of plastic pollution were mainly caused by huge dump of garbage as well as the result of tourism activities. Amongst the negative impacts of plastics pollution includes the destruction of anthropocene, unfavourable effects on the organisms, ecosystems and human health.

A number of countries have carried out various initiatives to reduce plastic pollution. These initiatives include Automatic Trash Collection Boat which is currently being established in China, Solar-powered Water Wheel Project which is carried out in Baltimore, a SeaVax from United Kingdom and many more. Although there are several initiatives that have been already practiced around the world, the demand of reducing plastic wastes on the water surface keeps on increasing as this plastic pollution is still a threat to human, living creatures and environment. Hopefully with the new proposed design, it could help to scale down the amount of plastic wastes. Apart from this, the new proposed design was created and produced so that it is applicable to be used anywhere and more importantly, it was designed to suit for the Bruneian context. However, the main important steps that need to be taken is to create awareness among the world population of the negative impacts of plastic pollution.

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