The Design and Analysis of Self-Cleansing Trash Trap for Capturing Floating Debris at the Drainage System

by

Mohamad Aliff Aiman bin Sharifudin

24584

Dissertation submitted in partial fulfilment of|
the requirements for the
Bachelor of Civil Engineering (Hons)

JAN 2021

Universiti Teknologi PETRONAS
32610 Seri Iskandar
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

The Design and Analysis of Self-Cleansing Trash Trap for Capturing Floating Debris at the Drainage System

by

Mohamad Aliff Aiman bin Sharifudin

24584

Final report submitted to the

Civil and Environmental Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfillment of the requirement for the

BACHELOR OF CIVIL ENGINEERING (Hons)

Approved by,

____

(Dr. Husna Binti Takaijudin)

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SERI ISKANDAR, PERAK

Jan 2021

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or person.

(MOHAMAD ALIFF AIMAN BIN SHARIFUDIN)

ABSTRACT

Industrialization and human error had caused severe water pollution. Initiatives to combat the problems have been done thoroughly such as installing trash trap but it seems like it needs improvement on some parts. For instance, the installation of a fixed position trash trap around the world needs regular maintenance from the local authorities to maintain the efficiency of the trash trap. Thus, it involves manpower and cost to keep it running. This project aim is to develop an effective self-cleansing trash trap which is able to reduce the maintenance cost of existing Gross Pollutant Trap (GPT). Thorough analysis was carried out based on the previous field data at Sungai Lumut Kiri which the depth of water with the presence of debris is 0.44 m become 0.3 m base on simulation by HEC-RAS software. Based on site visit, in average there are 31 debris per 1m x 1m proportion. The design of self-cleansing trash trap (SCTT) is performed in this study based on Urban Stormwater Management Manual for Malaysia (MSMA). The design was performed in 3D models using Autodesk AutoCAD software with 2 design option. The first design is 2m x 2 m dimension with 0.3 m height where the second design is 2 m x 1.8 m with 0.3 m height.

ACKNOWLEDGEMENT

Praise to Allah SWT, I managed to complete this final year project in time. Thanks to His Mercy and Grace, I get the opportunity to learn and improve myself with the knowledge while doing this paper. This study will never be completed without His approval.

In addition to that, there are a few names that deserve special attribution as without their help, I would have difficulties in completing this paper. First and foremost, special thanks to Dr Husna Takaijudin for supervising and guiding me into completing this paper. Without her guidance, I would not success to complete this study. It is a pleasure to be under her supervision for this final year project.

I would also like to express my gratitude to my family, Madam Zanizah bt Saharuddin, Mr Sharifudin bin Rastam, Nurain Hidayah, Nur Sufiah Alia and Mohamad Aliff Ashman. They had been supportive towards me as I am doing this final year project at home. Learning online is not easy but without their support, it will be impossible.

Finally, my highest gratitude to my friends that had been overwhelming and helpful to the end of my final year journey. Thanks to Amir, Faris and Iqbal for the emotional support which helps a lot to complete this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Project Background

Water pollution has become a main issue for all the developing countries all around the globe. The urbanization and industrialization of the world had led to most of the water pollution problems. Humans continue to move forward with the time by building and exploring all kinds of places without considering about the effect of their action to the environment especially water. A British poet once said, “Thousand have lived without love, not one without water”. As all know, water is the most importance substance as all of the living things need water to grow and live. Out of 100%, 71% of the Earth is covered by water. However, human continues to pollute the water without taking into consideration about the consequences of their actions. There are lots of floating debris in the water that had been dumped by the mankind whether it is deliberate action or an accidental one.

Floating debris is one of the main pollutants in the water. It consists of plastic, metal, wood, paper etc. Because of the urbanization nowadays, the number of plastics produced by the factory increase exponentially. Based on Glascock (2016), annually there are about 8 million tons of plastic that escapes to the ocean and it is predicted that there will be 1 ton of floating debris for every 3 ton of fish in the sea. Therefore, prevention must be done to lower the amount of pollution caused by floating debris. Using trash trap is a way to prevent the catastrophe from happening as it could capture the floating debris from flowing downstream and straight to the ocean.

Trash trap or Gross Pollutant Trap is an initiative made by man to capture the floating debris and other type of pollutant in the drainage system or streams. The system will trap the floating debris but at the same time still allowing the water to flow freely. In result, the downstream of the stream will be free of floating debris. However, majority of the existing GPT in the world often needs maintenance in order to remove the trapped debris. This incur a high cost to maintain the trap but still it is better than letting the debris to flow downstream. In this study, a self-cleansing trash trap is going to be designed and proposed to combat the high maintenance cost to remove the debris.

1.2 Problem Statement

The main issue from floating debris problem is it is causing flood at the study area, Sungai Lumut Kiri and at the same time is interrupting the flow characteristics of the drainage system. According to Water and Irrigation Department (JPS) Manjung, floating debris problem at the area is not a new problem as it had been around for about 15 to 20 years. The presence of debris in the river as it runs through an urban area which illegal dumping into the river were done by some irresponsible people.

Next, the floating debris in the drainage system that is located nearby to the sea which caused water pollution from upstream and to the downstream area i.e. coastal area. According to Jang, et al., (2014) most of the floating debris in the ocean flows from the river. With high and low tide of the sea, it causes the debris in the ocean and the riverbank to be gathered in the river.

1.3 Objectives

Objectives:

1. To analyze the flow characteristics of the river with and without floating debris.
2. To design a self-cleansing trash trap to capture the floating debris in the drainage system.

1.4 Scope of Study

This study is based on the floating debris problem that is causing a lot of problems in the world. Thus, to counter this problem, a self-cleansing trash trap were designed as it will require less maintenance to maintain the particular trash trap. As stated in the problem statement, floating debris contribute to interruption of the flow characteristics of drainage system and environmental problems which are flash floods and ocean pollutions. Thus, the designed trash trap will help to improve the flow condition in the area. The flow characteristics of the drainage design will be based on a case study in Sungai Lumut Kiri, Perak located at 4°13'60" N and 100°39'0" E with an elevation of 6 meters above sea level. Analysis of the flow characteristics were done to see the difference of the flow with and without floating debris. Then, a hydrostatic calculation was done to see whether the floating debris will become stagnant or flowing with the water. The self-cleansing trash trap were modelled to provide a clearer view on the design using AutoCAD 3D. The idea of the design is the same with Type 1 GPT but to make it self-cleansing, some tweaking of the design will be done to achieve the desired goal.

CHAPTER 2

LITERATURE REVIEW

2.1 Floating Debris Problem

Floating debris has becoming a global problem to majority of the water body and it is worrying as it could leads to numerous of problems. The presence of floating debris in the water body could be from deliberate or accidental action from human, urban discharge, and runoff on the surface to the water (Gasperi et al., 2014). Floating debris is made up of various type of components such as plastic, glass, and papers. Most of the debris are not a decomposable material, thus resulting to high number of pollutants in the water body. According to Jang (2014), approximately 159,800 tons of debris annually and large portion of the debris was a land-derived debris. The debris were brought down from the upstream of a drainage and have high possibility to flows into the ocean especially when the location is nearer to it. The presence of floating debris in the drainage leads to number of impacts such as health hazard to the surrounding area as it become the breeding habitat for some organisms and could lead to flooding. Other than that, floating debris could cost a fortune for the local authorities to clean up the affected areas.

2.2 Effects of Floating Debris

With the industrialization and rapid urbanization, waste management have been a major problem to many developing countries as it could contribute to flooding (Lamond, 2012). Debris in the drainage system leads to stagnant water body and higher water profile. The floating debris have blocked the waterway in the drainage as the accumulation of the trash in a low flow rate leads to a stagnant water. Plus, with the presence of the debris, it could contribute to some head loss to the water. With said, the water level at the area which have high number of floating debris will increase and become one of the factors of flooding. The flooding occurs because of the backwater effect at the drainage system as the floating debris that is accumulate at the downstream forms a debris dam. Generally, debris dam consists of any man-made or natural materials that are hoarded along the extent of the drainage system.

2.3 Gross Pollutant Trap (GPT)

There are several GPT basic design based on a few standards across the world. In Malaysia, MSMA Chapter 10 become the main reference for the basic design of the GPT. According to MSMA, GPT are installed to remove litter, debris, coarse sediment, and hydrocarbon from a water body. In GPT, it is divided into 3 classes according to their application. Table 2.1 shows the class of the GPT and its function.

Table 2.1: Type of GPT

Class	Function	Catchment Area	Installation
Type 1 Floating Debris Trap	Little capture on permanent waterbodies	> 200 ha	Proprietary and purposely built
Trash Racks & Little Control Devices	Little capture on drainage conveyance	2 - 40 ha	Purposely built from modular components
Type 2 Sediment Basin and Trash Rack (SBTR) Traps	Sediment and litter capture on drainage conveyance	5 - 200 ha	Purposely built
Type 3 Oil and Grease Interceptor	Oil, grease and sediment capture on drainage conveyance	< 40 ha	Purposely built and proprietary

There are two components of GPT that falls under Type 1 category. First one is floating debris trap or also known as boom. According to MSMA, boom will be in use if there is a steady current at the area and if the velocity of the water is not too high. This is because boom is a permanent trap and depends solely on the flow of water. Moreover, boom is only suitable in an area if it has an easy access for maintenance purposes. Figure 2.1 shows the example of floating debris trap. Second component of Type 1 category is trash racks and litter control devices as in Figure 2.2.

Trash rack is basically the screen which consists of several horizontal bars set with a specific angle to the flow. The size various according to the site condition. Trash rack supposedly is a self-cleansing trash trap as with specific angle of the horizontal bars will allow the trash to move towards the side of the rack. Next, according to MSMA, litter control devices are a "sock" that is made up of nylon mesh material. The device will be mounted onto a frame which is vertical and perpendicular to the flow. This type of GPT needs high amount of maintenance as lacks maintenance would result to slower flow capacity of the drainage.

Figure 2.1: Floating Debris Trap

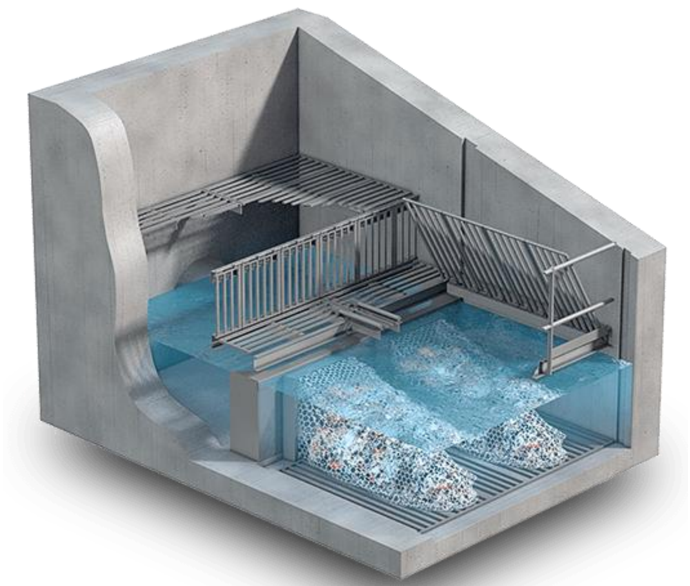

Figure 2.2: Trash Rack and Litter Control Devices

Next, Type 2 category of GPT consists of Sedimentation Basin and Trash Rack (SBTR). It is a combination of two components which are sedimentation basin and a trash rack. It works by slowing down the velocity of the water by building a bigger area of basin to trap the sediment at the bottom. Because of its incapability to remove litter, trash rack is installed to catch the litter at the system. SBTR are divided into major SBTR as in Figure 2.3 and minor SBTR as in Figure 2.4. According to MSMA, major SBTR are usually installed to intercept medium to large flow of stormwater while minor SBTR works in-ground. Because of the practicality of the minor SBTR, it is usually being used at residential areas and due to its size, the cost needed for maintenance is significantly lower than major SBTR.

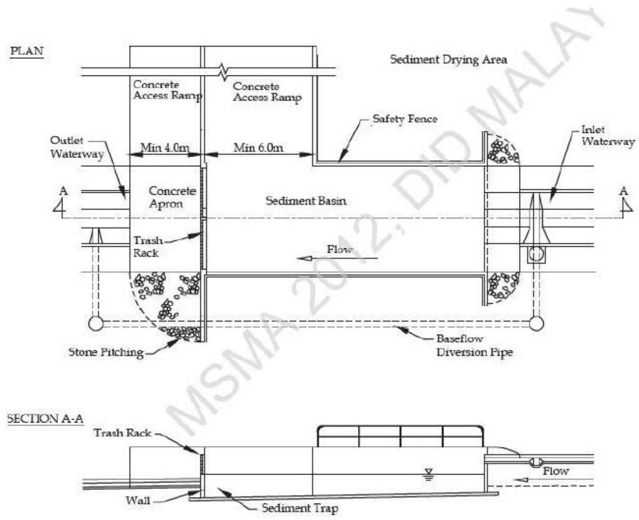

Figure 2.3: Major SBTR

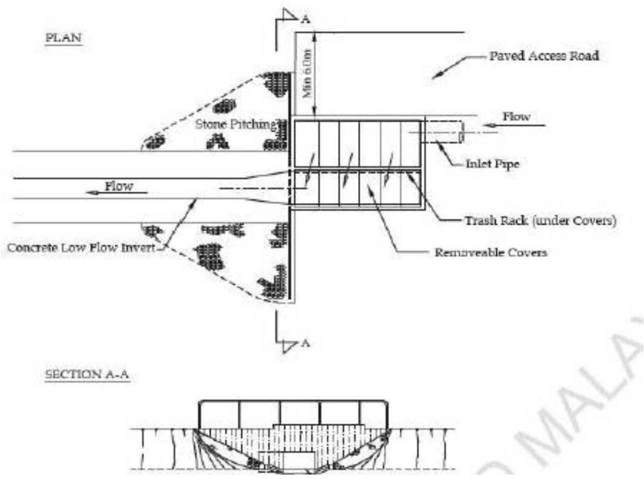

Figure 2.4: Minor SBTR

The last type of GPT according to MSMA is Type 3 which consists of Oil and Grease Interceptor. This type of GPT is mainly to be used to catch the runoff from impervious surfaces and pretreat them before the runoff enters a stormwater system. Based on MSMA, the function of this GPT is to isolate oil and other hydrocarbons, grit and coarse sediments from the runoff. Generally, there are three chambers in the Oil and Grease Interceptor. First chamber is used to trap all the floating debris and at the same time let the sediment in the runoff to settle to the bottom. The second chamber is to separate the oil and other hydrocarbon before the water flows into the third chamber. In the third and last chamber, it acts as a retention pool as the outlet pipe is elevated. At the same time, it lets the remaining sediments to settle to the bottom of the pool. Figure 2.5 below shows an example of Oil and Grease Interceptor.

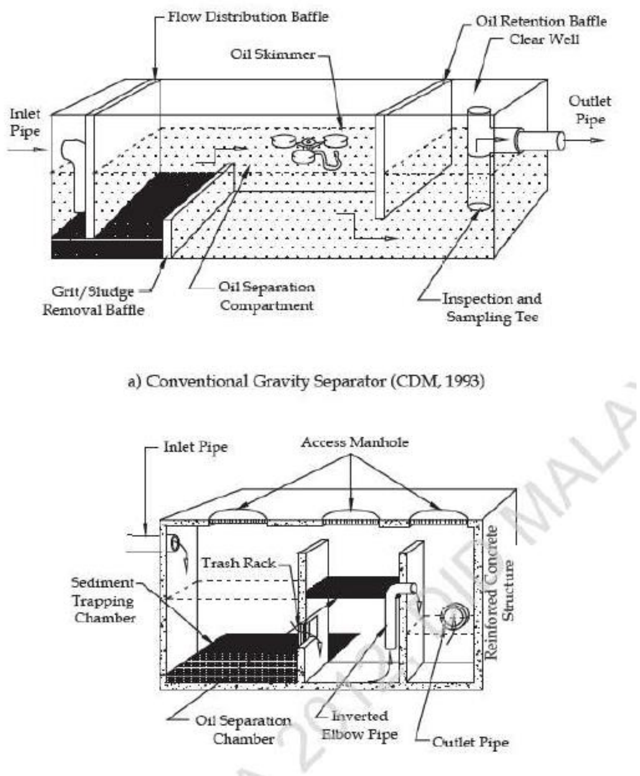

Figure 2.5: Oil and Grease Interceptor

2.4 Gross Pollutant Trap (GPT) Effectiveness

GPT main purpose is to trap the pollutant in the water system and reduce the amount of pollutant to flow downstream. Pollutants are made up of materials such as plastics, metal, paper, cans etc. (Ab Ghani, et al., 2011). Pollutant problems are caused by the industrialization and the urbanization of the world. The amount of plastic production is getting higher as it increases from 1.7 to 288 million tons for the past 60 years (Gasperi et al., 2014). Thus, the installation of GPT is crucially needed to prevent from higher amount of pollution in the world. GPT is a quite effective solution to the floating debris problem as GPT has the capability to improve certain water quality parameter downstream of its installation. According to Sidek et al., (2016), the installation of GPT promote a higher removal efficiency of biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), ammoniacal nitrogen (NH_3-N) and total suspended solids (TSS). This shows that GPT have great influence and aquatic habitat can be improved downstream. Other than that, GPT installation prove that it can increase the Water Quality Index (WQI) of a drainage system. In Sungai Klang, the upstream of the river was classified as Class V with WQI below 31 while the downstream is in between Class IV and Class III (Sidek et al., 2016).

2.5 Capacitive Sensor

Capacitive sensor is a sensor that could detect the presence of any materials. According to Moermond, 2017, a capacitive sensor works like a simple capacitor. He stated that in the sensing works by 2 plates where the first plate relates to the internal oscillator circuit electrically and the target that is sensed will acts as the second plate. In simpler terms, the target completes the circuit in capacitive sensor and allow the sensor to work. Figure 2.6 shows the illustration of the inside of the capacitive sensor. The sensitivity of capacitive sensor can be adjusted accordingly which allow more room for versatility.

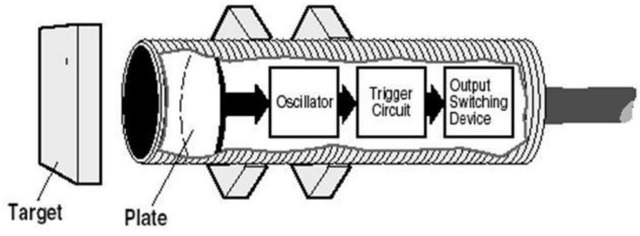

Figure 2.6: Capacitive sensor

Capacitive sensor is widely used to detect material such as plastic, paper and glass. According to Ahmad (2016), capacitance proximity sensor is dependable to detect non-metal material especially paper and plastic. Plus, it able to recognize the material and save the time to do manual separation. With the material that have low permittivity value, the capacitive sensor is able to detect without any hassle.

CHAPTER 3

METHODOLOGY

3.1 Overall Research Methodology

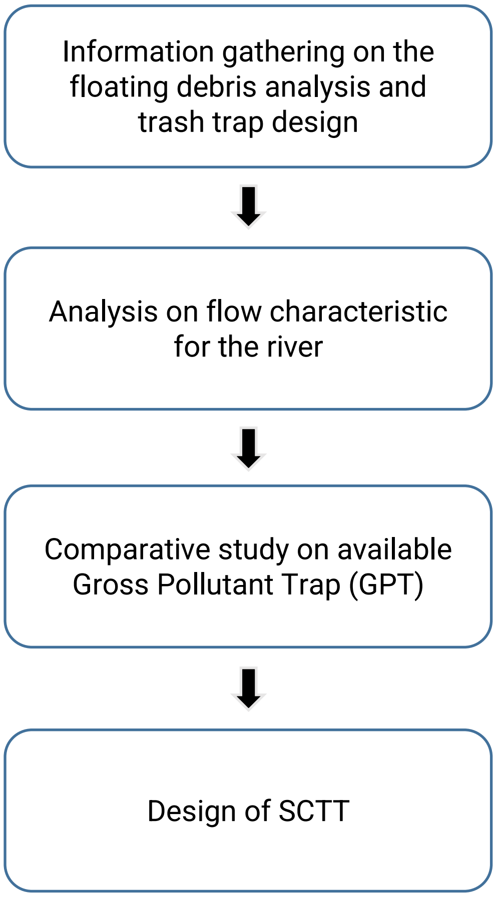

Figure 3.1: Overall Research Methodology

3.2 Study Area

Sungai Lumut Kiri is a small stream that is located in Manjung District in Perak. The river flows through residential, school and shrimp breeding pond. The river is approximately 6 meters from the sea level. Manjung is a district that is located just nearby the coastal area; thus the river flows directly to it. The location is being selected as it acts as one of the main catchments area plus the pollution to the stream is quite bad.

Figure 3.2: Sungai Lumut Kiri

Due to its location that is nearby the residential area and school area, there are vast number of floating debris that can be seen. The presence of the floating debris at the area produces a really bad odor to the surrounding area and in the event of high tide and heavy rains, flooding will occur. Other than that, the presence of the shrimp pond at the area plus with their illegal discharge of water into the stream, the water become black and turbid. Figure 3.3 and Figure 3.4 shows the floating debris accumulated in Sungai Lumut Kiri.

Figure 3.3: Debris problem

Figure 3.4: Downstream of Sungai Lumut Kiri

3.3 Analysis of Flow Characteristics of the Study Area

Floating debris is affecting the flow characteristics at the study area. A study had been conducted to see the flow characteristics such as depth, flow rate and flow velocity. The data that are needed to conduct this analysis were obtained from previous study. Flow measurement at the site was used to determine the flow characteristic with floating debris. For the flow characteristic without floating debris, data from HECRAS software were used as it capable to simulate the flow condition without any disruption from the debris. Analysis was done for the worst-case scenario at the study area which are at the time of high tide. During high tide, there are a lot of floating debris in the system which favors to the study objective which is to design a SCTT in order to remove the debris.

Floating debris amount in the area were calculated in 1m x 1m proportion to estimate the concentration of the debris available in the river. However, for the study area, the specific material for the debris were not stated. Thus, assumption is made based on the data collected downstream of the area which most of the debris in the river is plastic bottle.

With the amount of floating debris, hydrostatic calculation were done to determine whether the floating debris is stagnant, flowing with the flow or in buoyant state. The illustration was shown in Figure 3.5. Based on Archimedes principle, there are 3 condition that the debris will fall into which are:

1. $F_B > W$; the body will float on the surface
2. $F_B = W$; the body will be in suspended state
3. $F_B < W$; the body will sink to the bottom

Where,

F_B = Buoyant force

W = Weight of debris

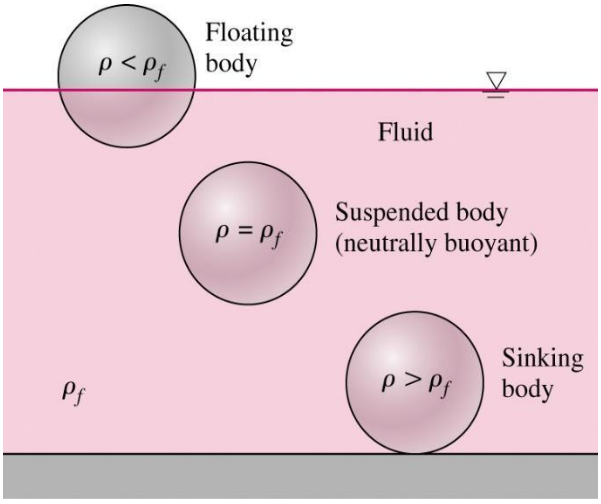

Figure 3.5: Body condition

Buoyant equation was used to determine in which condition the debris will fall into. To calculate the F_B, the following equation was used:

$$F_B = \rho_f g V$$

ρ_f = 1027 kg/m^3 ; density of sea water

g = 9.81 N/kg; force of gravity

V = Volume of area

Then, the weight of the debris will be calculated according to the area affected with the following equation:

$$W = \rho_d g V$$

ρ_d = 1027 kg/m^3 ; density of sea water

g = 9.81 N/kg; force of gravity

V = Volume of area

This study is using density of sea water because of the location of the study area. It is nearby to the coastal thus it is assumed that the density changes.

Plastic material in the river was assumed to be high-density polyethylene as polyethylene is the main material in any plastic bottle. Taking the worst case, high density polyethylene was selected with the density of 930 kg/m^3. Table 3.1 shows the density of plastic that was normally used in production.

Table 3.1: Density of plastic

Plastic Type	ρ (kg/m^3)	T_m (°C)
Polyethylene terephthalate (PET)	1350–1390	255
High-density polyethylene (HDPE)	930–970	125
Polyvinyl chloride (PVC)	1100–1450	210
Polylactic acid (PLA)	1200–1450	155–165
Poly-3-hydroxybutyrate (PHB)	1300	180
Polyethylene furanoate (PEF)	1400–1550	225

Except from plastic, other material might exist in the study area. Thus, two other material which are slippers made from rubber and glass were taken into account. The density for both of the material is in Table 3.2.

Table 3.2: Material density

Material	Density (kg/m^3)	Material	Density (kg/m^3)
Air	1.29	Iron, cast	7209
Aluminium	2691	Kerosene	817
Asphalt	1506	Lead	11342
Brass	8394	Limestone	2739
Brick, common	1794	Manganese ore	3204
Bronze	8715	Marble	2.56
Cement, Portland	1506	Mortar, rubble	2483
Cement, Portland (set)	2483	Nitrates (loose)	1602
Chalk	2195	Oils, mineral	929
Plasticine(wet)	3124	Paper	929
Coal (anthracite)	1554	Petroleum, crude	881
Coal (bituminous)	1346	River mud	1442
Coke	1202	Rubber	1520
Concrete masonry	2323	Sand	1602
Copper ore	4197	Sandstone	1442
Copper (cast)	8680	Steel	7769
Corn (bulk)	593	Tin	7337
Glass	3140	Water (pure)	1000
Gravel	1922	Wood (dry – red cedar)	380
Gold (24ct)	1929	Wood (dry – yellow pine)	700
Ice	920	Zinc	7049

3.4 Designing Self-Cleansing Trash Trap (SCTT)

3.4.1 Channel Geometry

To determine the dimension of the SCTT, the channel geometry was calculated first using the comparison of the peak flow, Q_{peak} and the designed flow, Q. The geometry shape design will be in trapezoidal shape with reference to the cross section of the channel.

The following equation were used to calculate the overland flow time, t_o, average rainfall intensity and the peak flow, Q_{peak}.

Overland flow time, t_o:

$$t_o = \frac{107nL^{\frac{1}{3}}}{S^{\frac{1}{5}}}$$

Where:

L = Overland sheet flow path length (m)

n = Horton's roughness value for the surface

S = Slop of the overland surface (%)

Average rainfall intensity:

$$i = \frac{\lambda T^{\kappa}}{(d+\theta)^{\eta}}$$

Where:

I = Average rainfall intensity (mm/hr)

T = Average recurrence interval

d = Storm duration (hr)

λ, κ, θ, η = constant based on rain gauge location

Peak flow:

$$Q_{peak} = \frac{CiA}{360}$$

Where:

C = Runoff Coefficient

i = Average rainfall intensity (mm/hr)

A = Drainage area (ha)

There were a few parameters that were followed and assumed in the calculation:

- Velocity of the designed drainage will be in the range of 0.6 m/s to 2.0 m/s to prevent any sedimentation and soil erosion.
- Manning's coefficient for this channel was assumed to be 0.035 according to the study area and Table 3.3 shows the value of the Manning's coefficient.

Table 3.3: Manning's roughness coefficient.

Material	Typical Manning roughness coefficient
Concrete	0.012
Gravel bottom with sides	
- concrete	0.020
- mortared stone	0.023
- riprap	0.033
Natural stream channels	
Clean, straight stream	0.030
Clean, winding stream	0.040
Winding with weeds and pools	0.050
With heavy brush and timber	0.100
Flood Plains	
Pasture	0.035
Field crops	0.040
Light brush and weeds	0.050
Dense brush	0.070
Dense trees	0.100

- The peak flow determination is based on major ARI where T=100 years.
- Fitting constant for the average rainfall intensity was based on JPS Setiawan automatic rainfall gauging station as in Table 3.4.

Table 3.4: Derived IDF parameters of high ARI

State	No.	Station ID	Station Name	Derived Parameters			
				λ	κ	θ	η
Perak	1	4010001	JPS Teluk Intan	54.017	0.198	0.084	0.790
	2	4207048	JPS Setiawan	56.121	0.174	0.211	0.854
	3	4311001	Pejabat Daerah Kampar	69.926	0.148	0.149	0.813
	4	4409091	Rumah Pam Kubang Haji	52.343	0.164	0.177	0.840
	5	4511111	Politeknik Ungku Umar	70.238	0.164	0.288	0.872
	6	4807016	Bukit Larut Taiping	87.236	0.165	0.258	0.842
	7	4811075	Rancangan Belia Perlop	58.234	0.198	0.247	0.856
	8	5005003	Jln. Mtg. Buloh Bgn Serai	52.752	0.163	0.179	0.795
	9	5207001	Kolam Air JKR Selama	59.567	0.176	0.062	0.807
	10	5210069	Stesen Pem. Hutan Lawin	52.803	0.169	0.219	0.838
	11	5411066	Kuala Kenderong	85.943	0.223	0.248	0.909
	12	5710061	Dispensari Keroh	53.116	0.168	0.112	0.820

- The channel's peak flow was based on MSMA guidelines on rational method.
- Sub catchment area is 8.3 ha with a slope of 2%.

3.4.2 SCTT Modelling

With the analysis and calculation that had been done, the dimension of the SCTT were determined. The modelling of the proposed design for the SCTT were done in AutoCAD 3D software. The SCTT are consists of crusher and conveyor system where it is capable to crush the debris that were collected and transport it to the collection bin at the riverbank.

Figure 3.6: AutoCAD Logo

Based on the cross section, the size of the trash trap was determined. This self-cleansing trash trap is a floating debris trap hybrid with a self-cleansing mechanism which could lower the maintenance cost for the local authority.

The modelling of the trash trap was done using Autodesk AutoCAD in 3-dimensional to provide a clear view on the trash trap.

3.5 Gantt Chart

Table 3.5: FYP 1

No	Project Activities	Week											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Title Selection												
2	Collecting data and information												
3	Reviewing all finding and material												
4	Methodology drafting												
5	Proposal defense												
6	Flow characteristic analysing												
7	Documentation of interim report												

Table 3.6: FYP 2

No	Project Activities	Week											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Comparative study on GPT												
2	Design self-cleansing trash trap												
3	Altering design												
4	Preparation for Viva and FYP report												
5	Viva presentation												
6	FYP report submission												

CHAPTER 4

RESULT AND DISCUSSION

4.1 Flow Characteristic Analysis

With the data of the HEC-RAS simulation and the site measurement gathered from previous study, the analysis was done by comparing the flow characteristics with and without the presence of floating debris. The data is based on the same channel geometry at Sungai Lumut Kiri which the width of the channel is 7.54m. The deepest depth of the channel is 1.14 m while the water surface elevation varies based on the site measurement and HEC-RAS simulation. These geometries were measured based on the site condition.

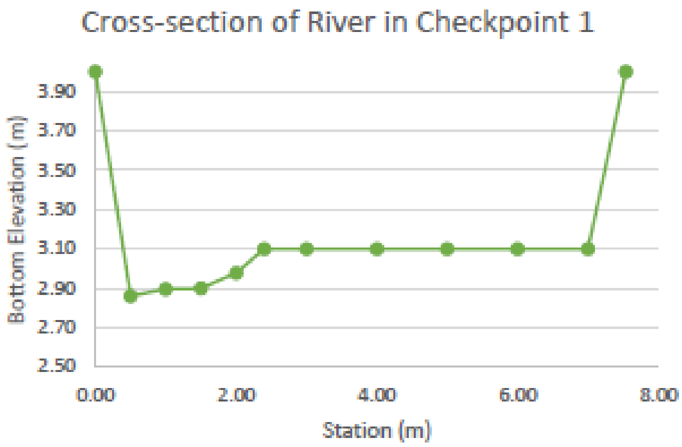

Figure 4.1: River Cross Section

4.1.1 Flow Characteristics without Floating Debris (HEC-RAS)

The flow rate, velocity and water surface elevation were shown in the result. The data is simulated at the highest water depth at high tide which is PF3. Based on the result in Table 4.1 and Figure 4.2, the average flow rate, Q is 0.18 m^3/s, average velocity is 0.22 m/s and the flow depth is 0.3 m.

Table 4.1: HEC-RAS Simulated Data

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Upper Reach	100	PF 3	0.18	2.86	3.2		3.2	0.000516	-0.18	1.01	6.71	0.15
Upper Reach	90.000*	PF 3	0.18	2.86	3.2		3.2	0.000543	-0.18	0.99	6.71	0.15
Upper Reach	80.000*	PF 3	0.18	2.85	3.19		3.19	0.000576	-0.18	0.98	6.71	0.15
Upper Reach	70.000*	PF 3	0.18	2.85	3.19		3.19	0.000616	-0.19	0.96	6.7	0.16
Upper Reach	60.000*	PF 3	0.18	2.85	3.18		3.18	0.000667	-0.19	0.93	6.7	0.16
Upper Reach	50.000*	PF 3	0.18	2.85	3.17		3.17	0.000735	-0.2	0.91	6.7	0.17
Upper Reach	40.000*	PF 3	0.18	2.84	3.16		3.17	0.000833	-0.21	0.87	6.69	0.18
Upper Reach	30.000*	PF 3	0.18	2.84	3.16		3.16	0.000975	-0.22	0.83	6.68	0.2
Upper Reach	20.000*	PF 3	0.18	2.84	3.14		3.15	0.001216	-0.23	0.78	6.68	0.22
Upper Reach	10.000*	PF 3	0.18	2.83	3.13		3.13	0.001718	-0.26	0.7	6.66	0.25
Upper Reach	0	PF 3	0.18	2.83	3.1	2.99	3.11	0.004005	-0.33	0.54	6.64	0.37

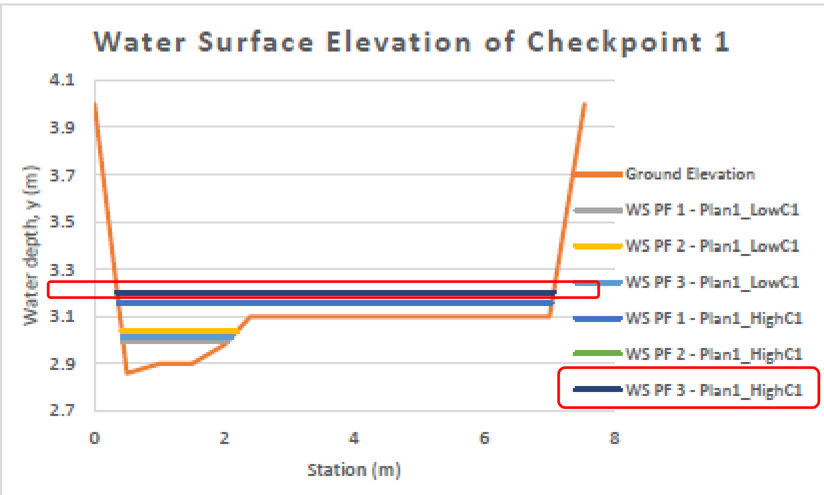

Figure 4.2: HEC-RAS Water Surface Elevation

4.1.2 Flow Characteristics with Floating Debris (Site Measurement)

In Table 4.2 below, the data from the site measurement shows that the velocity is 0.251 m/s, flow rate is 0.092 m^3/s and the highest depth is 0.44 m.

Table 4.2: Site Measurement Data

Area	Width	Avg Depth m	Area m2	Avg Velocity m/s	Flow m3/s
1	1	0.18	0.175	0.01	0.002
2	1	0.32	0.32	0.025	0.008
3	1	0.32	0.315	0.029	0.009
4	1	0.4	0.395	0.037	0.015
5	1	0.44	0.435	0.054	0.023
6	1	0.43	0.425	0.049	0.021
7	1	0.39	0.38	0.033	0.013
8	0.54	0.17	0.092	0.014	0.001
				0.251	0.092

When comparing between both HEC-RAS and site measurement, the flow characteristics are a bit different. The simulated flow rate is higher than the site measurement data. However, the depth of the site measurement is 0.44 m which is deeper compared to HEC-RAS simulation which is 0.30 m. The water surface elevation might be influenced by the presence of the floating debris in the river. Based on Archimedes principle, the floating debris displaced the water in the river thus increasing the depth of the river.

4.1.3 Floating Debris Mass and Hydrostatic Calculation

The amount of floating rubbish were recorded in 1m x 1m proportion. The data for the floating debris count at the area is shown in Table 4.3 below.

Table 4.3: Amount of rubbish

Location	Area	Amount of rubbish (1m x 1m)	Average pcs/m2	Weight (g)	Total Weight (kg)
CP1	Area 1	35	31	6.41	0.19871
	Area 2	30			
	Area 3	28			

Due to unavailability of the specific data in the study area, data from downstream of the river were used to provide assumptions. Table 4.4 shows the type of rubbish accumulated while Figure 4.3 shows the summary of the rubbish accumulated in pie chart.

Table 4.4: Rubbish Accumulated

Area	**Plastic bottles**	**Aluminum can**	**Slippers**	**Polystyrene**	**Others**
Area 1	17	1	3	1	10
Area 2	14	3	4	0	6
Area 3	12	4	1	9	5
Average	14	3	3	4	7

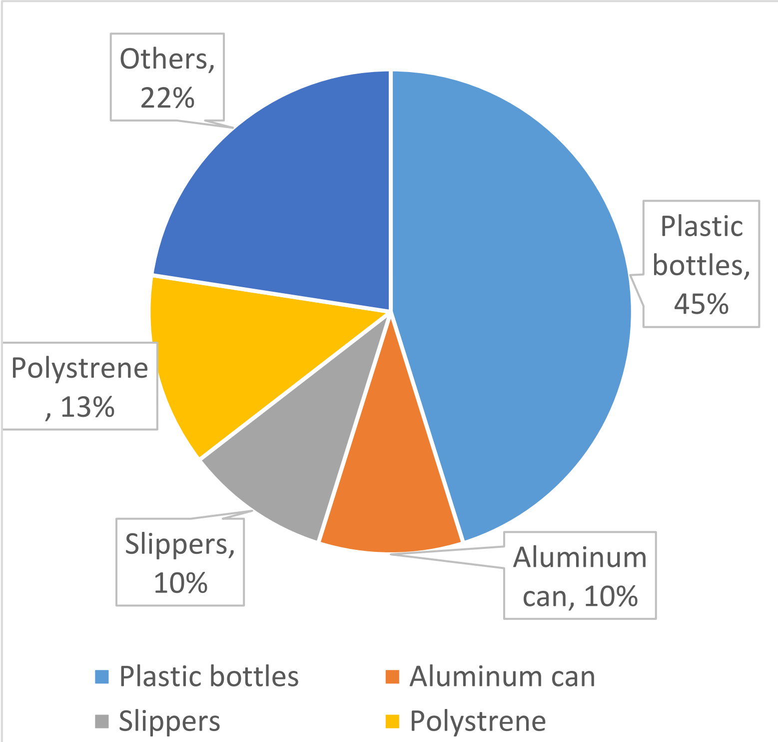

Figure 4.3: Rubbish Accumulation Summary

The first scenario is when the whole area is flooded with plastic. The weights of the plastic were calculated and compared with the buoyant force of the water. The width of the river is 7.54 m and the length where the rubbish accumulate is about 15 m.

Volume	= Water depth x area
	= 0.44 m x 7.54 m x 15 m
	= 49.764 ≈ $50\ m^3$
F_B	= (1027 kg/m^3 x 9.81 N/kg x 50 m^3) / 1000
	= 503.74 kN
Weight of plastic	= (930 kg/m^3 x 9.81 N/kg x 50 m^3) / 1000
	= 456.17 kN

F_B is greater than the weight of plastic. It does not influence the flow of water as the plastic will be floating on the surface.

The second scenario is when the area is full of plastic alongside with other material which are rubber slipper and glass. It is assumed that rubber slipper takes 40% of the rubbish and glass takes 30% of the rubbish in the area.

Weight of rubber = [(1520 kg/m^3 x 9.81 N/kg x 50 m^3) / 1000] x 40%

= 298.22 kN

Weight of glass = [(3140 kg/m^3 x 9.81 N/kg x 50 m^3) / 1000] x 30%

= 462.05 kN

Total weight of debris = 456.17 kN + 298.22 kN + 462.05 kN

= 1216.44 kN

F_B is lower than the total weight of the debris. Thus, most of the debris will be sink to the bottom of the river.

With accordance to the result, it is seen that debris with high density such as rubber slipper and glass contribute to accumulation of rubbish in the river bed. However, the debris that are floating such as plastic can be collected using the SCTT that are designed.

4.2 Design of Self-Cleansing Trash Trap

4.2.1 Channel Geometry based on Peak Flow and Design Flow

In reference to MSMA guideline for rational method calculation, the peak flow was determined. Table 4.5 below shows the calculation with respect to the 100 years ARI at the study area.

Table 4.5: Peak flow calculation

Steps	Values
Overland flow time, t_o: $$t_o = \frac{107(0.035)(20)^{\frac{1}{3}}}{(0.02)^{\frac{1}{5}}}$$	= 15.24 minutes
Average rainfall intensity (mm/hr): $$i = \frac{(56.121)(100)^{0.174}}{(0.254 + 0.211)^{0.854}}$$	= 240.48 mm/hr
Peak flow, Q_p: $$Q_{peak} = \frac{(0.775)(240.48)(8.3)}{360}$$	= 4.297 m^3/s

With the peak flow, Q_p that had been calculated in Table 4.5, channel cross section that can cater the peak flow was determined. Design flow was calculated using estimated depth which then compared to the peak flow. Based on Dayana (2020) study on the channel, the parameters were gathered as follows:

- Manning's coefficient, n = 0.035
- Channel longitudinal slope, S = 0.4%
- Side slope, z = 1.5
- Bottom width, b = 6.5 m

Table 4.6 shows the calculation of the channel geometry with a designed flow rate, Q that was capable to cater the peak flow, Q_p of the channel.

Table 4.6: Channel Geometry

Water Depth (m)	Area, A	Wetted Perimeter, P	Hydraulic Radius, R	Velocity, V	Q_{design} (m^3/s)
0.6	5.52	8.66	0.637	0.423	2.336
0.8	8.08	9.38	0.861	0.517	4.179
1.0	11.0	10.11	1.089	0.605	6.654

The required channel geometry were calculated and the result were as following:

Depth = 1 m

Top width = 9.5 m

Bottom width = 6.5 m

Velocity = 0.605 m/s

Q_{design} = 6.654 m^3/s > Q_{peak}

Thus, the dimension of the designed trash trap should be lower than 6.5 m to accommodate the channel's bottom width.

4.2.2 SCTT Model and Design Option

Due to the water condition and the hydrostatic calculation, the best type of trash trap that were used were floating trash trap. The designed trash trap are capable to perform self-cleansing process where the floating debris in the water will be crushed using a screw-like crusher and the crushed debris will be transported to the river bank using conveyor belt. There are two primary design that had been modelled for this project. Both of the design will have 3 crusher, conveyor system, flaps and sensor. The design were combined with floating boom to direct all of the floating debris into it.

4.2.2.1 First Design Options

For the first design, the 3D model is as Figure 4.4 below. Floating debris will go through the first gate (1) where there are sensor and arm installed. The debris that is made from plastic will go inside the first compartment where it will be crushed and deposited to the bottom of the crusher. In the bottom, there is a conveyor belt that transport the crushed debris onto the riverbank. For gate 2, only glass will go into the compartment and the rest of the debris will go into the third compartment. In the model, there are 3 compartments that the debris can go to according to their material composition.

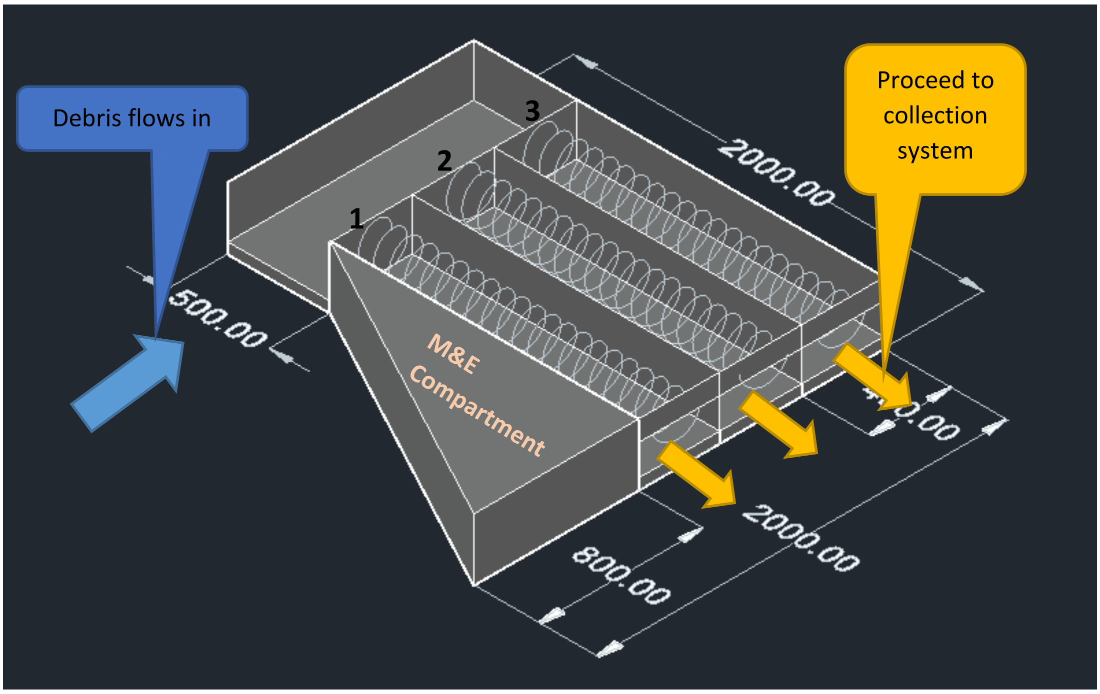

Figure 4.4: First Design Option

To direct the debris into the SCTT, floating boom were used. Figure 4.5 below shows the plan view of the SCTT with the floating boom.

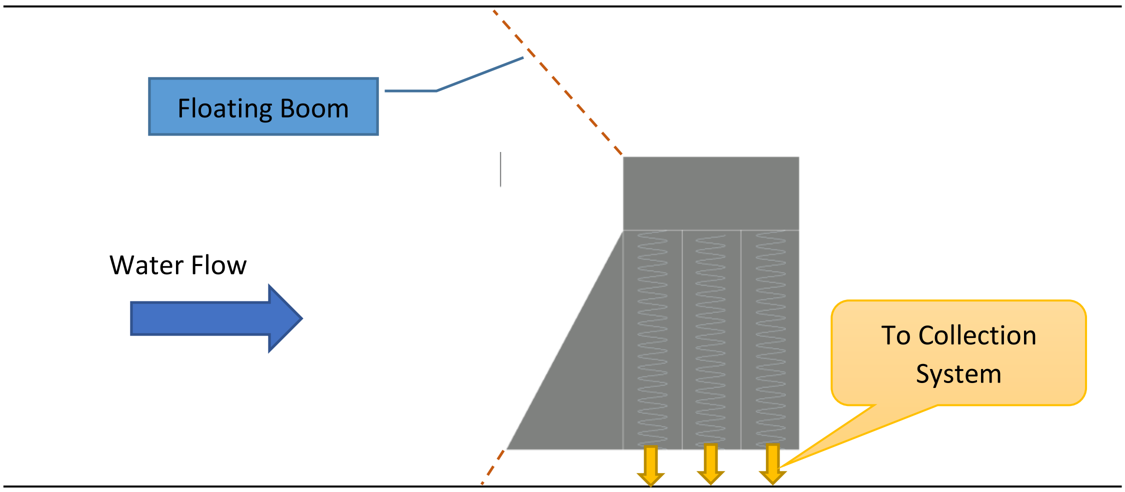

Figure 4.5: Plan View of Design 1

4.2.2.2 Second Design Option

For the second design, the debris will go through the main gate where arm and capacitive sensor were installed. The sensor will detect and sort the debris to their respective section according to their material composition. Then, the debris will be crushed and deposited to the bottom of the trap where conveyor belt are located. Crushed debris will be transported to the riverbank for collection. In the model, there are 3 compartment that the debris can go to according to their material composition. Due to the design, the collection bin must be put on both side of the riverbank. The 3D model of the design is as Figure 4.6 below.

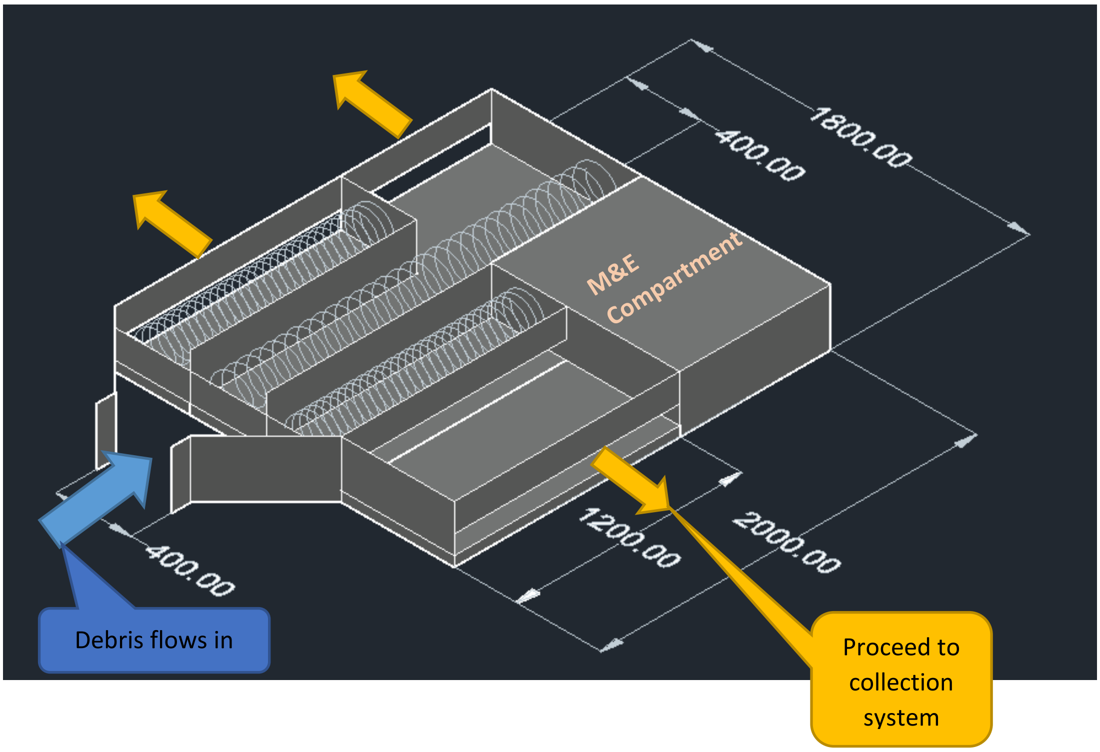

Figure 4.6: Second Design Option

Same with design 1, floating boom is used to direct the debris into the SCTT. Figure 4.7 below illustrate the plan view of the SCTT with the floating boom.

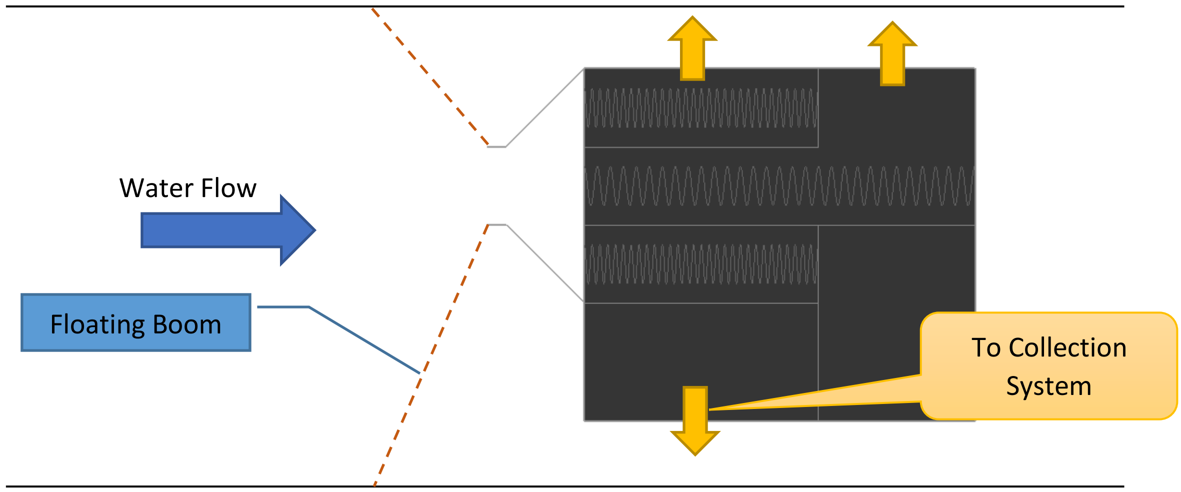

Figure 4.7: Plan view of Design 2

For both of the design, the conveyor system to the riverbank have some limitation. It needs a proper site measurement and mechanical views as the river bank is higher than the water surface level. Thus, it need to have a specific type of conveyor that is durable to the weather.

4.2.2.3 Comparative Analysis

Two design were proposed to combat the floating rubbish problem as the study area, Sungai Lumut Kiri. In functionality view, both of the design could carry out their function which are to collect the floating debris and self-cleanse. However, there are some differences between both designs. Table 4.6 shows the comparison between design option 1 and 2.

Table 4.7: Comparative Analysis

Design	1	2
Differences	- Require 3 set of capacitive sensor and arm. - Easy to install conveyor system at the bottom and the crushed debris will not mix up. - Convey the crushed debris to one side only.	- Require 1 set of capacitive sensor and arm. - The conveyor system need to be separated into 3 section to avoid the crushed debris to mix up. - Convey the crushed debris to both side.

Both of the design are facing the same problem with the conveyor system. Improvements can be made in future research to implement the designs at any area that is experiencing floating debris problem. In term of economic value, Design 1 is much economic compared to Design 2. This is due to the number of the collection bin needed,

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study has achieved its objectives which are to analyse the flow characteristic and design a self-cleansing trash trap. Floating debris problem is a major problem not only at the study area but in the world. The river or any water body are being targeted as a dumping area by some irresponsible people which led to flooding, accumulation of rubbish and bad odor. Water bodies that is near to a residential area or any popular area often become a victim of this floating debris problem.

The design of the floating self-cleansing trash trap was successful and based on the comparative analysis, Design 1 is the most suitable to be implemented at Sungai Lumut Kiri. It is because of the easiness to install and maintain the conveyor system plus with the limitation of capacitive sensors which is not capable of recognizing each material successfully. Plus, the mix up of the crushed debris can be avoided as it can be recycled straight away. Nevertheless, Design 2 can be improved in the future to make it more feasible to be done. However, the conveyor system needs to be revised in order to make a physical model of the design.

5.2 Recommendation

To improve the design and accuracy of this study, there are a few recommendations that can be done:

1. Detailed design on the trash trap. This is to ensure that any errors in the design stage had been corrected before starting to build the physical model of it. The machineries that are going to be put inside the trash trap must be fit into it in order to allow the trash trap to function effectively.
2. Sensor related. One of the reasons that Design 2 is being outcast is because of the sensor limitation which it is limited to sense only 1 material.
3. Conveyor collector system. The riverbank is far higher than water surface level. Views from mechanical person is much needed to design a proper conveyor system.

REFERENCES

Ab Ghani, A., Azamathulla, H. M., Lau, T. L., Ravikanth, C. H., Zakaria, N. A., Leow, C. S. & Yusof, M. A. (2011). *Flow Pattern and Hydraulic Performance of the REDAC Gross Pollutant Trap*. Flow Measurement and Instrumentation. 22. (3) 215-224.

Ahmad, I., Basri, H. & Mukhlisin. M. (2016). *Application of Capacitance Proximity Sensor for the Identification of Paper and Plastic from Recycling Materials*. Research Journal of Applied Sciences, Engineering and Technology. 12(12): 1221-1228.

Dayana Nabilah Nasa Radzie. (2020). *Hydraulic Analysis of Floating Rubbish in Sungai Lumut Kiri with HEC-RAS*.

DID. Urban Stormwater Management Manual for Malaysia (MSMA). Chapter 34: Gross Pollutant Trap.

DID. Urban Stormwater Management Manual for Malaysia (MSMA). 2nd Edition.

Gasperi, J., Dris, R., Bonin, T., Rocher, V., & Tassin, B. (2014). *Assessment of floating plastic debris in surface water along the Seine River.* Environmental Pollution, 195, 163-166.

Glascock, T. (2016). *The Problem of Ocean Trash*. Ocean Conservancy. https://oceanconservancy.org/blog/2016/08/22/the-problem-of-ocean-trash/

Jang, S. W., Kin, D. H., Seong, K. T., Chung, Y. H. & Yoon, H. J. (2014). *Analysis of Floating Debris Behaviour in the Nakdong River Basin of the Southern Korean Peninsula Using Satellite Location Tracking Buoys.* Marine Pollution Bulletin, 88, 275-283.

Lamond, J., Bhattacharya, N., & Bloch, R. (2012). *The Role of Solid Waste Management as a Response to Urban Flood Risk in Developing Countries, a Case Study Analysis.* WIT Transactions on Ecology and the Environment, 159, 193-204.

Moermond, J. (2017). *What is a Capacitive Sensor?* Automation Insights. https://automation-insights.blog/2017/06/07/what-is-a-capacitive-sensor/

Sidek, L., Basri, H., Lee, L. K. & Foo, K. Y. (2016). *The Performance of Gross Pollutant Trap for Water Quality Preservation: A Real Practical Application at the Klang Valley, Malaysia.* Desalination and Water Treatment. 1944-3944.