PROTECTORS OF MAHIGA

AQUARRIORS

RESEARCH REPORT AND SOLUTION PROPOSAL TO THE MIDSTREAM MAHIGA RIVER

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PART A: Research Paper

I. INTRODUCTION

The Mahiga River is a river in Cebu City that has a total length of 9.1 km with the midstream river located in Subangdaku near Innodata. In Figure 1, it can be seen that the river is going down to Subangdako Bridge near CityScape Tower for Midstream 1, Midstream 2 located in Subangdaku Bridge, Mandaue City and the downstream river located in Mabolo Reclamation Area.

Modeling and evaluating the river has recently raised significant interest among both practitioners and researchers. With urbanization, human activities have greatly influenced the health of bodies of water including Mahiga River. River pollutants such as industrial, residential and commercial wastes in Mahiga River pose significant health risks to close communities that surround the river stream for the aquatic environment, and utilization of the water that causes health issues. It affects the lifestyle of the people around the river as they utilize the river in their daily lives. It also harms the organisms living in the river because of how polluted the river is. This is why the Mahiga River has been identified as Class C classification by the DENR-Cebu, which means that the water is not suitable for drinking activities but only for agricultural or recreational activities.

The rehabilitation of the Mahiga River (reference) will aid the people who are living near the river and the ecosystem within the premises of the body of water. With that being said, understanding the issues regarding the situation can provide better details in providing a narrowed solution. The observation and the data being collected will be the basis to nurture possible solutions that are either innovative or a unique thought-out solution. Hence, the researchers will have to provide a firm theoretical and a practical solution that would benefit the community and also the natural environment with the help of the Local Government Units.

Figure 1.1. *Location of Mahiga River.*

1.1. Statement of the Problem

The cities of Cebu and Mandaue have been facing a natural disaster which is flooding for decades due to several factors including human actions of improper waste disposal and direct runoffs from the environment. It can be seen in Figure 2 of the observed condition of Mahiga River as the result of human activities where trash or plastics accumulate in different areas most especially near the bridge which could be a factor that would impede the flow of water and increase the risk of overflowing and flooding. Because of improper disposal and human activities, the water quality has been adversely affected and it is not suitable for the use of daily lives of residents like drinking or to be used for washing clothes.

Figure 1.2. *Water condition of Mahiga River.*

1.2. Objectives

Mahiga River's pollution and flooding pose as the main issues it faces. The main objective of this study is to identify and investigate the root factors that cause the Mahiga River pollution. Then it is needed to innovate a solution to improve the solid waste management and water quality health of the Mahiga River. After which the study shall help inform the public and local government units about the condition of Mahiga River and how to implement the best possible solution to resolve the Mahiga River pollution problem. Then it is needed for interdisciplinaries to work together for the implementation of the solution.

1.3. Significance of the Study

This study aims to bring awareness on the issues that led to the pollution of Mahiga River, specifically the Midstream portion. Moreover, it aims to provide a viable solution to improve the quality of the water health in the river to avoid any harmful substances to its surroundings. This is to prevent the spread of its diseases and waste brought upon to the river. Hence, the issue surrounding the Mahiga River can help interdisciplinary studies to innovate feasible solutions preventing more damage and instead help the rejuvenation of the river.

1.4. Research Question

Conducting this study will address the determination of the water quality of Midstream Mahiga River through different water parameters and the issues present. Moreover, we also take into consideration factors such as how the residents and nearby establishments make use of the river and the various categories of trash present in the river and along the riverbanks.

II. METHODOLOGY

The research methodology that was chosen in order to identify the root cause of the problem is Exploratory data analysis. Exploratory data analysis was chosen as the research methodology as it is the most effective way of monitoring water quality data (Vega, M. et al., 1998). It helps analyze the river pollution problem in the midstream of Mahiga River where garbage is generated. The data explored includes water parameters such as Nitrates, and Water Transparency.

2.1. Site Visit

A site visit of the Mahiga River was conducted where in the middle stream, the color of the river is evidently polluted due to the amount of garbage. The smell also is unpleasant as it is contaminated with the wastes in the river. Many people, homes, and vehicles pass by around the river resulting in them throwing their wastes or have direct runoffs into the river.

2.2. Interview

An Interview was conducted by the team between 5 local residents from different areas near the river. Out of the five interviewers, two were tenants living right next to the Mahiga River, two were staff members of establishments a few meters away from the Mahiga River and lastly, one was a member of a local government unit who is situated in the area and who was with the team during the research. The questions that were first asked were about consent on their participation in the River Scan Challenge by the USC Students. Afterwards, they were mainly asked about their experiences or memories of the Mahiga River in the past, the contribution/usage of the river, the issues of the river and their inputs on mitigating these issues affecting both the area and residents.

III. RESULTS AND DISCUSSION

3.1. Maximum Flood Height

The maximum flood height may reach above the river embankment which is due to the blocked flow of water due to the accumulation of trash in the river. Its maximum height reached approximately 18 inches above the river embankment.

Figure 3.1. *Measuring of Maximum Flood Height.*

3.1.2 Interview

The residents that were asked about the Mahiga River in which they live nearby, mentioned how the Mahiga River has always been polluted even way before. There have been no improvements done to the river in terms of maintenance and hygiene. They claim that people throw their trash away in the river. This is due to the negligence of the LGU when it came to collection of trash in the area. If ever they do clean, it will only be done when asked by the government through clean up drives that don't happen consistently. A working person near the river mentioned how the river should be constantly maintained cleanly as many kids play nearby the river and throw trash unconsciously. They also mentioned how they are aware that the river is polluted so whenever it rains hard, the place gets easily flooded as water and trash come from upstream to their area. This results in water pollution in the river, that is why they have started to segregate trash in the proper disposal areas and ask for help from the LGUs to maintain their monthly check-up on the river.

3.2. River Width Using Smart Measure App

One of the parameters measured is the width of the river where it is the distance between the points where the water comes into contact with each riverbanks. Using the Smart Measure App in Android devices, one would be able to calculate the distance between the phone and the target object in front using the camera which is similar to LiDAR. With an average interval of 1.6 meters between points, results showed that the average width of Mahiga River Midstream near Innodata is approximately 5.4 m.

POINTS	WIDTH (m)	Average Width (m)
1	5.5	5.4
2	5.1	
3	5.5	
4	5.6	
5	5.3	

Table 3.1. *Summary of Results for River Width.*

3.3 Urban Water Quality

Mahiga River, which is situated in the urban area of Cebu City, is highly vulnerable to urban flooding and water quality problems. Thus, determining the water quality of the river is helpful in creating

concrete solutions that could address future detrimental effects towards the area where the river is located. In this assignment, 3 samples of water were collected on the middle portion of the river and one of the sample bottles was tested on a Nitrate and pH test through dipping strips in the water samples. Results showed a 0 nitrate value which does not coincide with the visual appearance or observation of the Mahiga River during the ocular and fieldwork visits. This could possibly be due to the followings reasons: (1) the measurements could be faulty, (2) the nitrate is bound to other chemical substances so it does not show up in the nitrate test, and (3) nitrate is not available but it does not mean that the river has good water quality or is drinkable since there are a lot of factors to consider when measuring the drinkability of the water. Despite these possible circumstances, the poor quality of the river can be justified through the other experiments conducted specifically the Secchi disk wherein the transparency of the water is measured up to 18 cm. Moreover, results from the pH test shows that the river has a pH value of 8.4 which is slightly high compared to the usual pH value of river which is 7.4. With the values accumulated, it has shown that the water tested may contain organic and inorganic materials that pollutes the water. These values also show that with low levels of chlorine, the water is more prone to disease-causing germs and hazardous. Measurements obtained from the water tested are shown on the table below.

SUBJECT	OUTCOME
Nitrate	0 ppm
Phosphate	40 ppm
Total Chlorine	0 ppm
Free Chlorine	0 ppm
Total Hardness	338 grains per gram
Total Alkalinity	240 ppm
pH level	8.4
Transparency of Water (Secchi Disk)	18 cm

Table 3.2. *Summary of Results for Urban Water Quality*

3.4 Riverine Plastic Waste Pollution

Figures 2.2 and 2.3 showcase the estimation of plastic pollution in the riverbanks and floating through the midstream Mahiga river. Experimentation for plastic waste was conducted by generating a quadrant of 1 square meter (1 m²) and randomizing different points in the accessible riverbanks and areas of the river. Overall with numerous classifications of plastic wastes, Figure 2.3 reveals that in the elevated riverbank of midstream Mahiga, unidentifiable medium plastic constitutes to most of the plastic wastes while the least is from plastic bags and wrappers. In contrast to the data collected in the riverbanks, the category on plastic bags and wrappers greatly contributed to the plastic wastes floating in the river. Based on the results of the tests, the floating plastic pieces per 1 m² is 48 plastics belonging to slightly polluted while the plastic pieces per 100 m riverbank is 243 plastics belonging to the polluted category. The data on plastic pollution is an essential data in knowing the river's water quality and flood-prone risks which is valuable in identifying viable solutions and measures to mitigate the current issues experienced in the area.

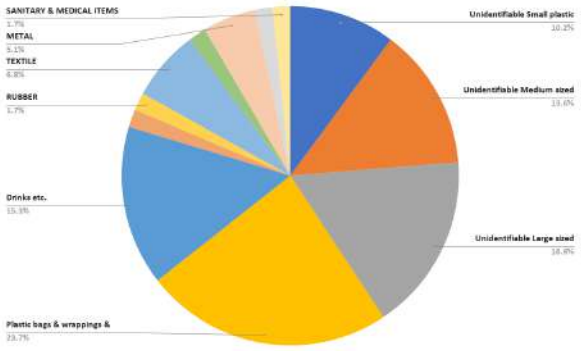

Figure 3.2. *Riverbanks*.

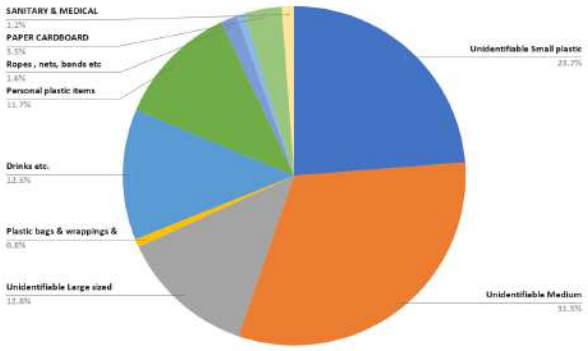

Figure 3.3. *Floating.*

3.5 Ecology of the River

Rivers are important sources of water for drinking and irrigation purposes. It also provides a habitat for aquatic organisms such as fish, plants, algae, crabs, insects and even shrimps. Once this ecosystem is polluted and degraded, not only will it affect the living organisms in the river but also human health. To monitor and determine the health of the river, miniSASS is conducted where a sample of macroinvertebrates are collected from the water and the sensitivity of each group of animals is taken into account. When performing the miniSASS method, two groups of living organisms were found, the uncased caddisflies and the true flies. Using the scorecard for miniSASS, the sensitivity score has a total of 11 and a miniSASS value of 5.5. As the Mahiga River Midstream is rocky, it is ecologically categorized as a poor condition, as presented in Table 2.5, where plenty of modifications should be made. As the river water is in poor quality, with it being full of garbage, it is difficult to find living organisms. Few reasons would be the sewage and wastewater which came from the toilet, sink and showers of the residents living near the river as well as toxic wastes that can contaminate the river water and eventually kill these organisms.

GROUPS	SENSITIVITY SCORE	SCORECARD
Flatworms	3	
Worms	2	
Leeches	2	
Crabs or Shrimps	6	
Stoneflies	17	
Minnow mayflies	5	
Other mayflies	11	
Damselflies	4	
Dragonflies	6	
Bugs or beetles	5	
Caddisflies (cased & uncased)	9	PRESENT
True flies	2	PRESENT

Snails	4	
TOTAL SCORE		11
NUMBER OF GROUPS		2
AVERAGE SCORE (miniSASS Score)		5.5

Table 3.3. *miniSASS Scorecard Results.*

Ecological Category (Condition)	River Category	
	Sandy Type	Rocky Type
Natural Condition (Unchanged/Untouched)	> 6.9	> 7.2
Good Condition (Few Modifications)	5.9 to 6.8	6.2 to 7.2
Fair Condition (Some Modifications)	5.4 to 5.8	5.7 to 6.1
Poor Condition (Lots of Modification)	4.8 to 5.3	5.3 to 5.6
Very Poor Condition (Critically Modified)	< 4.8	< 5.3

Table 3.4. *Ecology miniSASS Score.*

3.6 River Stream Velocity

The speed of the water in the river is indicated by its stream velocity. The stream's velocity, which rises as the volume of water in the stream does, determines the types of organisms that can live in a stream where some organisms require fast-flowing places, while others require quiet pools (EPA, 2012). It also has an impact on how much silt and sediment the stream carries. The impact of the stream velocity to water quality and the living organisms is important which makes the flow of water a crucial function of the stream's volume and velocity. This stream flow may be depleted as it can receive pollution discharges which may block the flow of a stream.

A flow method, where the basic idea is to measure the time it takes a floating object to travel a specified distance downstream was used to determine the stream velocity of Mahiga River (midstream). By choosing a suitable area with less turbulence, a 25 feet distance was marked as point A and B for the floating object to travel. A banana stem was used as the floating object to cross the upstream and downstream markers near the embankment and its time of travel was recorded. The process was repeated three times and accumulated the values 1.16ft/s, 1.13ft/s, and 1.22ft/ which gives an average velocity of the Mahiga river of 1.17 ft/s. To be able to get the channel area measurement, 10 depth readings were taken across the width. Summary of data is shown below.

Depth 1	Depth 2	Depth 3	Depth 4	Depth 5	Depth 6	Depth 7	Depth 8	Depth 9	Depth 10
8	13	17	22	19	24	34	32	40	48

Table 3.5. *Depth Readings in cm.*

Since surface velocities are typically higher than the average overall velocity, it is multiplied by 0.85 to be more representative with the slower velocities which gives an adjusted velocity of 0.995 ft/s. This then gives us a CFS of 0.15. Since there are trashes that have piled up in certain areas of the river, the velocity may have been affected which would vary because of those persisting trashes that could possibly slow the flow of the river.

3.7 Turbidity with Secchi Disk

Turbidity is one of the general indicators of water quality which refers to the cloudiness or amount of suspended particles in the water or river that impair the ability to see clearly through it (Porter, 2002). In short, it is the measure of transparency or clarity of the water. Professor Boyd from the Department of Fisheries and Allied Aquacultures in Auburn University revealed in his article in 2004, "Secchi disk visibility: Correct measurement, interpretation," that Secchi disk reading values of less than 20 or 30 centimeters indicate excessive or high turbidity which signifies low water clarity and indicating presence of suspended particles or other substances that may be harmful to the water. Moreover, high turbidity is due to several factors including surface run-off and pollution. The results of the conducted test at the shady area of the river was found to be around 18 centimeters disclosing the water in Mahiga River Midstream has high turbidity or cloudiness where it is not very clear.

TRIAL	DEPTH (not visible)	DEPTH (visible)	AVERAGE DEPTH
1	19.4 cm	17 cm	18.2 cm
2	19.4 cm	17.5 cm	18.5 cm
3	20.1 cm	17 cm	18.6 cm

Table 3.6. *Turbidity with Secchi Disk.*

IV. CONCLUSION AND RECOMMENDATION

Mahiga river's midstream 2, which is located along Subangdaku Mandaue City (right in front of Innodata), was examined through gathering data and experiments to know more about the river's current situation. Upon examining the area itself, the team can evidently see the trash that floats and stays on the water. Because of this improper disposal of waste, it contributes to the natural disaster of flooding. With this problem in mind, the team aims to provide a solution to mitigate the flooding situation and to figure out ways on how the Mahiga river could be less of a burden to the community.

As the team gathered more data about the Mahiga river, it was discovered that it is highly vulnerable to urban flooding and has problems when it comes to its water quality. As the team interviewed random people residing or working near the area, the team discovered the problems the Mahiga river brings to the community. From the five interviewees, they all had one problem in common - the flooding in the area and the trash that comes with it. The interviewee shared an estimate level where the flood reaches which is 18in.

Water was also tested using Nitrate and pH tests through dipping strips in the water samples. From the samples taken, results showed a 0 nitrate value which does not coincide with the appearance of the river. The team acknowledges that there may have been errors when it came to collecting the data.

These errors were that the measurements could be faulty, the nitrate is bound to other chemicals and lastly the nitrate is not available.

In reality, rivers are important sources of water for drinking and irrigation purposes. It is expected to be clean for use and clean enough to act as a habitat for aquatic organisms. With just one look at the river, it is clear that it definitely is not the case. As the team conducted further experiments to support the case, it was determined that there are factors that contribute to its poor quality. One would be trash and poor drainage coming from the upstream, poor government maintenance, and the different chemicals and liquids being thrown into the river. These are just one of the few factors that contribute to the poor quality of the Mahiga river.

Moving forward, the team aims to cater to the problem of flooding in the area that is caused by poor disposing of waste caused by trash being dumped in the river causing clogging which leads to flooding in the area. The team aims to improve the catchment of the river by innovating a new system that will help in preventing trash from flowing to the downstream portion of the river. Innovating this while working together with the local government unit can help make a difference in preventing floods in the area.

To further develop the study, the team also recommends having plants placed along or on the river that will help in filtration. The use of water hyacinth, an invasive aquatic plant found in the Pasig River, is a plant that is being used to reduce heavy metals and nutrients in the river. Water hyacinth, water lettuce, duckweed, fairy moss and floating ferns are just a few of the possible floating plants that can be used. Marginal (emergent) plants as well as submerged can also be used as it is great for oxygenating water in addition to absorbing nutrients. This recommendation is something that needs further research to see if these specific plants are readily available or if they are good use for solving the problem of the water quality in the Mahiga River.

V. REFERENCES

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PART B: Practical Solution

This part of the study presents the problems of the Mahiga River and its solutions to help improve and prevent issues that damage the river body. The group primarily focused on the problem of the river that causes flooding which limits the solution in a more specific way in order to give proper information and awareness to the public. The solution for solid waste is to implement the catch net of the river in order to prevent roughness that creates flooding. Reducing the amount of waste in the river will additionally help as well with the water quality since there will be less waste so the water will not be contaminated. Implementing a secure policy for the public to follow will help prevent the solid waste accumulating in the river as well as improving its water quality due to lesser waste buildup.

B.1. Design of the Solution

Numerous concerns and problems are caused by the river's complexity, including solid waste, flooded areas, poor water quality, and squatter settlements. With no proper care by throwing waste in the river, it can cause problems that are harmful for the environment and to the public. To address these issues primarily on the solid waste and water quality of the river, the group has decided to propose a solution for both problems. This can reduce solid waste and filter out the water in the river.

The proposed solution that the group decided is called Aquarriors Filter System (AFS), a block and tackle system that can help prevent solid waste. There will be three floating fences diagonally in the river that differ in the sizes of the hole. The nearer it is to the end catch net, the smaller its dimensions which means it will catch even the smallest of wastes. The fences act like a sift for the waste depending on the magnitude of the waste and it floats with the water level of the river. The waste will then be collected on the furthest point of the fence or at the side near the riverbank due to the water flow of the river which is shown in figures presented below. As soon as the river contains an enough amount of waste, another cage/block with holes (*see Figure B.1*) initially placed downward will be pulled from the ground through a pulley system in order to catch the waste or plastics accumulated at the side. This triangular figure is opened at the top and has small holes sufficient enough to hold small plastics whilst allowing water to pass through it. Also, the bottom of the triangular cage can open and close for easy disposal of the waste. A railway will be constructed in which the pulley system will be attached vertically beside the river to allow it to move from point to point depending on where each floating fence is placed. The estimated distance between floating fences is around 5-10 meters.

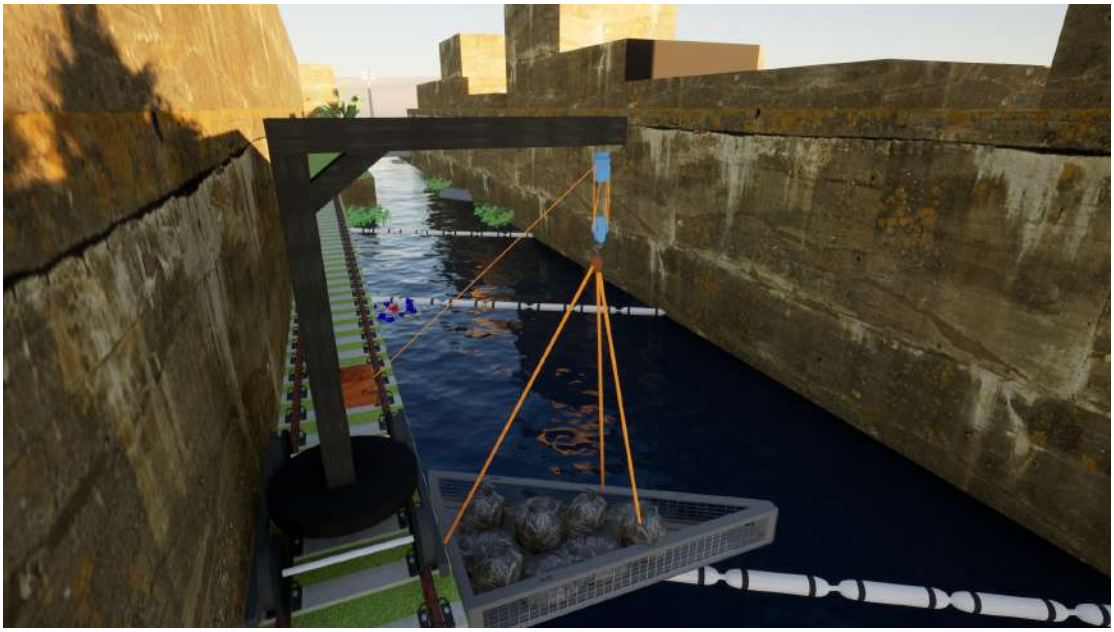

Figure B.1. Aquarriors Filter System *(white = floating fence)*

Figure B.2. Top View of AFS

Figure B.3. Top View of the Whole Stretch of the Midstream Mahiga River

B.2. Locational Analysis

Taking into consideration that the river comprises varying depths, it is most preferable to install the AFS into the portion of the river that is not shallow. Moreover, existing catchnets in the Mahiga are installed near the bridge and the lack of maintenance results in the accumulation of trash from the whole stretch of the midstream portion of that particular area in the river. With our solution, we plan to install the AFS in the area from the upper portion of the midstream stretch towards the bridge *(see Figures B.4. & B.5.).*

Figure B.4. *Location Installment of the Proposed Solution.*

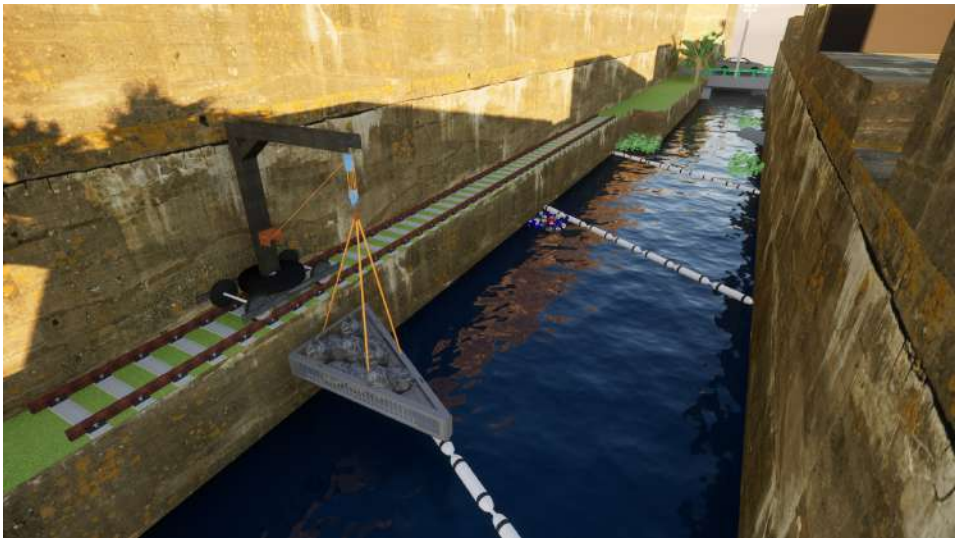

Figure B.5. *Location Installment of the Proposed Solution.*

B.3. Social Cost-Benefit Analysis with Explanation

Taking the action of the proposed solution opens the view for social value and environmental sustainability which may be advantageous. Moreover, assessing the benefits may also have its disadvantages. A Social-cost benefit analysis is conducted to look into an alternative or potential project without partiality and pursue innovative initiatives that benefit the residents and landowners in the area.

For this proposed project, its social cost includes disturbance in the process of building the project. This also includes the construction cost needed for the completion of the project. The necessary maintenance is also costly as it will need fixing and repair in the operation. The pulley system and railway also need its maintenance as it is prone to corrosion which may adhere to the operation to be faulty when failed to do so. Although there are established social costs, the social benefits of the project are of greater significance as the project prevents or mitigates flooding, which is one of the primary issues experienced in the area. It also improves the water quality, the living conditions for the residents and landowners, and the overall atmosphere of the river.

Cost of the Project

Different factors are considered for the costing of the project which includes the construction materials, labor cost for making and installation of the AFS as well as for the maintenance cost. The total estimated cost for this project will be around P20,000 based on the prices of the materials in the Philippines. The group also proposes the use of recycled materials that would suffice in the creation of the AFS to lessen the cost.

Materials	**Price (Php)**
Steel Beams	55
Polypropylene Rope	44/meter

Polycarbonate Plastic (Twin Wall Sheet)	400/4ft.
Stainless Steel Sheet	120
Floating Fence (Metal)	1,000

Table B.1. *Prices of Materials of the Proposed Solution.*

Funding for the Project

Both Mandaue City and Cebu City LGUs must work together and agree on the funding of this project since the areas affected by this project involve both cities. Additionally, partnerships with private companies or individuals such as those situated near the river can help support the funding of this project as it helps mitigate the current issue of flooding experienced in the area.

B.4. Planning

According to R.A. 9003 otherwise known as the Ecological and Solid Waste Management Act of 2000, the Local Government Units are responsible for the implementation and enforcement of provisions. For the proposed solution to be implemented and adopted by the LGU, they first have to survey the specific area of the river in which they will assess the community or people living around the area. Then when the area is clear for implementation of the device, the final planning shall take place with orientation of the local government officials and the residents of the community.

B.5. Stakeholders Involved

The proposed project is an integrated effort involving not only local governments but also appointed people, the residents, landowners, and private establishments in the surrounding area. Considering they are all using the river and thus contributing to the problem, it is only reasonable for them to help realize the solution through simple means such as effective trash and wastewater disposal. Together with the financial aid and participation of the LGUs, as well as the residents in the area, the occurring problem that may affect the living condition of these individuals would be resolved.

B.6. Operation and Maintenance

As the waste or plastics are trapped and accumulated at the side of the river by the AFS projects, one resident living near the river is appointed to be responsible for monitoring the area through CCTV. Moreover, any Barangay official or member who assists those in authority will be regarded as an agent of those in authority. These individuals may include those charged by law or ordinance with maintaining public order, safeguarding lives and property, or maintaining a desirable and balanced environment.

As part of the maintenance of the proposed project, it would be advantageous to appoint a resident living near the river to be responsible for monitoring the area. Specifically, he/she is tasked to monitor the wastes or plastics accumulated in the “filter” through the installed CCTV camera/sensor located in the bridge (*see Figure B.6.*) or manually going to the location. In addition, the proposed project incorporates use of the existing alarm system (horn and CCTV) through testing it, fixing, and maintaining its operation. Once waste is abundant enough at the side of the river, he/she contacts and alerts the people

from the LGU to collect and dispose of the waste in the designated dump site. The service of this point person is to be compensated with a pay. On top of that, everytime the river is being cleaned or wastes are collected and disposed of, the responsible individual checks whether the AFS works well. In any case that any component malfunctions, it is then checked and fixed automatically.

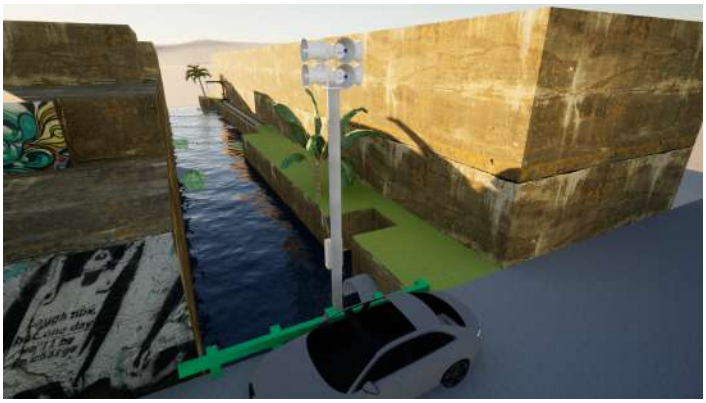

Figure B.6. Existing System at Subangdaku Bridge