“ASSIGNMENT 1 : RESEARCH REPORT AND INNOVATIVE SOLUTION PROPOSAL”

MAKING WAVES

METRO CEBU RIVER SCAN CHALLENGE

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INTRODUCTION

Pollution is the process of making land, water, air, or other aspects of the environment unfit for human use. This can be accomplished by introducing contamination into a natural habitat; however, the contaminant does not have to be palpable. When purposely brought into an area, even simple things like light, sound, and temperature may be deemed pollutants (Bradford, 2023). Water pollutants are compounds that pollute water and can be detrimental to humans and the environment. Water pollution is therefore defined as any alteration in water that is damaging to living creatures (Letchinger, 2000). The Butuanon river was one of the major water sources of residents before it was declared dead in 1992. It stretches from the mountainous area of Cebu City down to Mandaue City. The river flows downstream passing through Cebu City and has its mouth in Mandaue City near the Magellan Bay. The Butuanon river has the governmental Recreational Water Class C II for boating, fishing or similar activities. The Department of Environment and Natural Resources (DENR) Region 7 reports that the river has been used as a dumping area of residential, industrial, commercial, and agricultural wastes. DENR Region 7 reports that Butuanon river was classified as class driver in 2000, which means that it is no longer safe for human recreation and consumption.

The scope of this study is the downstream area of Butuanon river located in Brgy. Umapad Mandaue City, Cebu dumpsite area.

Statement of the Problem

The main problem of the study is the water pollution and flooding in downstream Butuanon river. In order to resolve this occurring problem this proposal is undertaken to answer the following queries:

1. What are the major types of chemical pollutants present in the river? What are the sources of these chemical pollutants?
2. Is the downstream Butuanon river prone to flooding caused by natural weather phenomena(e.g. Heavy rains, typhoons, thunderstorms etc.)
3. How much is the amount of plastic waste pollution at the downstream Butuanon river? What is its corresponding indication?

Objective of the Study

The main objective of the study is to propose a practical solution to resolve the existing issue of pollution in downstream Butuanon river. The specific objectives of the study are as follows:

1. Propose a sustainable, economical, and long term solution that could neutralize the chemical pollutants in downstream Butuanon river.
2. Propose a method that could mitigate the flooding in the area.
3. Propose a method that could help solve the water plastic pollutants(e.g. Plastic wastes, garbage, etc.) around the area.

Research Questions

The main research question of the study is to determine the existing pollutants(e.g. chemical, and plastic wastes) at the downstream Butuanon river that affects its water quality. The study specifically aims to answer the following sub-questions.

1. What are the most abundant chemical pollutants at the downstream Butuanon river? What are the methods that will help neutralize these chemical pollutants?
2. What are the sustainable methods that could be implemented to mitigate the flooding around the area?
3. What are the possible solutions that could solve the problem of plastic wastes in the downstream Butuanon river that are sustainable, eco-friendly, and have low maintenance?

METHODS

The researchers determined the existing pollutants(e.g. chemical, and plastic wastes) at the downstream Butuanon river by conducting fieldwork at Brgy. Umapad Mandaue City, Cebu. A series of on site tests were conducted to investigate the; geographical features of the downstream Butuanon river(e.g. width, depth,etc.), maximum flood height, the water quality of the river, streamflow velocity, plastic waste pollution, and turbidity.

The geographical features of the river, such as the width, was measured using a smart measuring app that can be installed in mobile phones and was performed in five trials. The maximum flood height of the river was measured by asking a local and pointing out what is the elevation of water during extreme flood events, the maximum flood height was obtained by measuring the vertical distance between the maximum flood height point and the bottom of river embankment. In case of the water quality of the river, the fieldworkers conducted an on site test that could measure the following urban water quality parameters; Nitrates concentration, pH levels, Alkalinity concentration, total hardness, total chlorine concentration, free chlorine concentration, and phosphates concentration. The concentrations of these parameters are obtained using test strips performed in three trials , where each test strip for each parameter is dipped in the water. The concentrations and pH results are read using the color difference in the test strip which tells a certain measurement in ppm. The nitrates concentration is read using Deltares, a mobile application that can measure concentration of nitrates by taking an image of its test strip color difference. The collected data from these parameters are essential in drawing conclusions of the water quality of the downstream Butuanon river. On the other hand, the streamflow velocity was conducted by setting a 50 meter mark on the river path, marking the start and end points and throwing a floater in the river and marking the time it takes to travel the 50 meter distance. This method was done in five trials. The plastic waste pollution is assessed using Randomized OSPAR Riverbank Monitoring and Randomized OSPAR Floating Plastic wastes. Turbidity is measured using Secchi disk which helps in evaluating if the water could still support biota.

An ocular visit on the Butuanon river downstream area can help to create plans regarding the mitigation of flooding. Interviewing the locals will further support the mitigation plan of flooding.

RESULTS

The data gathered during the fieldwork on April 19 and 20 at the Umapad dumpsite yielded the results shown below, which were all documented and encoded. All relevant data and the approach to the river were taken into account from the completed ocular visit in order to reach the outcome.

Maximum Flood Heights

Maximum flood height described by locals are high during heavy rains and typhoons, during this event water does not overflow but during site visit and inspection we can also see that efforts of rehabilitation such as dikes made by the government are used therefore chances of overflow are avoided.

Table 1. Maximum Flood Heights.

RIVER	MAXIMUM FLOOD HEIGHTS(m)
BUTUANON (Brgy Umapad)	1.524

Width of River

The Butuanon River was recently the subject of rehabilitation and enlargement efforts, as seen by the DPWH report on April 16, 2023. The river's total width is 30 meters, while its actual water width was 15 meters. In this manner, both overflow and issues were resolved. Data gathered by the team are shown below.

Table 2. River Width

TRIALS	RIVER WIDTH(m)	AVERAGE
1	30.42	30.498
2	30.55	
3	30.65	
4	30.42	
5	30.45	

As a result, restoration and expansion initiatives can be seen and inferred from data collection.

Urban Water Quality

Water quality in cities has suffered significantly as a result of urbanization. As population density and industry have grown, water quality has become a severe issue for both human health and the environment. It is influenced by a number of elements, including human activities, industrial operations, agricultural practices, and natural processes, all of which have a substantial impact on water quality. Maintaining high water quality is critical for urban residents' health and well-being, as well as the long-term viability of ecosystems and the environment.

Table 3.Urban Water Quality

PARAMETERS	**TEAM 12**			**AVERAGE**
Sample #	1	2	3	
Nitrate/Nitrite(ppm)	0	0	0	0
pH	7.5	7.5	7.5	7.5
Alkalinity(ppm)	240	240	240	240
Total Hardness(ppm)	425	425	425	425
Total Cl(ppm)	0	0	0	0
Free Cl(ppm)	0	0	0	0
Phosphate(ppm)	10	10	10	10
Remarks	1	2	3	

Table 4. Urban Water Quality Indication

SUBJECT	**RESULTS**	**WHAT DOES THIS TELL YOU?**
Nitrate/Nitrite(ppm)	0	Nitrates in river water often range from 0.01-3.0 ppm. A nitrate-nitrogen reading in rivers that is less than 1.0 ppm is considered excellent. Whereas, a nitrate-nitrogen level greater than 10 ppm is considered unsafe to drink. Nitrate levels to protect aquatic life ranges from 3 ppm to 32.8 ppm. Therefore, the gathered data of 0 ppm of Nitrate-Nitrogen levels of water from Butuanon river is safe to drink.
pH	7.5	The pH level data falls within the optimal range of pH level for aquatic

		life to thrive in river ranging from 6.5 to 8.5
Alkalinity(ppm)	240	According to Soha(n.d) The normal alkalinity of river water ranges from 100 to 250 ppm. The alkalinity of Butuanon river is within the range having an alkalinity value of 240 ppm. Higher alkalinity in water buffers acids that prevent pH change that is harmful to aquatic animals - e.g.ammonia toxicity
Total Hardness(ppm)	425	The total hardness of water in Butuanon river downstream of 425 ppm is classified as very hard since it is >180 ppm. The acceptable TH limit is 100 ppm
Total Cl(ppm)	0	Based on the acquired data, there is no presence of Total Cl in the Butuanon river downstream
Free Cl(ppm)	0	Based on the acquired data, there is no presence of Free Cl in the Butuanon river downstream
Phosphate(ppm)	10	Phosphate levels in rivers should not exceed 0.1 ppm. Phosphates in excess of these amounts can be quite hazardous. Based on the data gathered, the phosphate concentration in Butuanon downstream is 10 ppm which is more than enough to cause nutrient pollution to plants and aquatic animals.

Based on the Urban Water Quality results table above, the nitrates, total chlorine, and free chlorine was found to have a 0 ppm concentration on downstream Butuanon. Moreover, the pH level is 7.5 which means the water pH level is basic. The Alkalinity concentration is 240 ppm which falls in the acceptable range. The Total hardness concentration is 425 ppm which is classified as very hard. The phosphate concentration is 10 ppm, relatively higher than the normal range of <0.1 ppm which will cause nutrient pollution to aquatic plants and animals.

Riverine Plastic Waste Pollution

Plastic pollution has been a major problem that is present in the entire world. It has reached into the water systems which affects the major source that every species uses. Rivers are one of the sources that have been destroyed due to plastic pollution. To be able to understand more about the ongoing waste pollution happening, OSPAR Riverbank monitoring

was conducted. These experiments help in understanding what are the pollutants occupying rivers, specifically the Butuanon River downstream and give a deeper understanding as to how grave the pollution is.

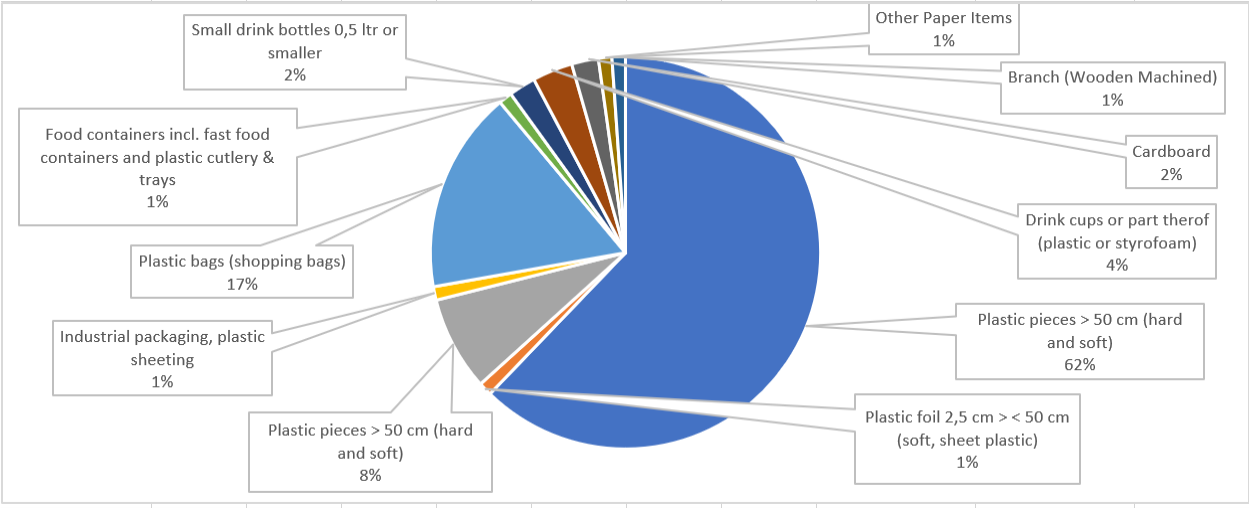

Figure 1. Riverine Litter Composition along downstream Butuanon river.

Riverine Plastic Waste						
Category	A	B	C	D	E	F
Pieces per $1m^2$ floating	0 - 1	2-5	6 - 25	26-50	51-100	100>
Pieces per 100 m riverbank	<10	10 - 50	51 - 250	251-500	501-1000	1000>
	(Almost) clean	Slightly polluted	Polluted	Severely Polluted	Heavily polluted	Extremely polluted

Figure 2. Plastic Wastes Category.

From the Riverine Plastic Waste Measurement Riverbank Form, A total of 90 items were retrieved using the net and were categorized. In the assigned area, the top 3 pollutants are the following: 62% was found to be plastics specifically Plastic pieces > 50 cm both hard and soft plastics, followed by Plastic bags (shopping bags) having 17% and lastly, Drink cups or part thereof having 4%. It can be seen that most of the pollutants found in Butuanon River are from plastics. This can be categorized as Category C - Polluted due to having 90 pieces per 100 m riverbank.

Ecology of the River

The Butuanon River is a major source of environmental resources in Cebu, Philippines and has an important role to play in the area's biodiversity. The species found in the river are

vital for the protection and conservation of its ecology. However, the river ecosystem continues to be in danger as a result of rapid urbanization and unrestrained human activity, endangering the ability of the area to survive. To minimize the negative effects of human activity and maintain the ecological balance of the Butuanon River, it is crucial to understand its ecology.

Table 5. Site Information Table.

SITE INFORMATION TABLE	
River name: Butuanon River (Umapad Area)	**Date:** 21/04/2023
Site name: Umapad Dumpsite	**Collector's name:** Group 12 (Making Waves)
GPS co-ord Lat(S): 10.3365714 **Long(E):** 123.9624594	**School/Organisation:** University of San Carlos
Site description: The type of riverbank is harbor wall where the area is considered as a dumpsite.	**Notes:** The river has been considered dead since 2000 however locals had sightings of living marine creatures.
pH: 7.5 **Water temp:** 40 ºC **Dissolved oxygen:** **Water clarity:** Murky black	

Table 6. Ecology Scorecard

Groups		**Sensitivity Score**
Local Name	**Scientific Name**	
Crabs	Scylla serrata	5
Tilapia	Oreochromis niloticus	2
Bulan-bulan	Megalops cyprinoides	2
Ito/Hito	Siluriformes	1
Toad	Ingerophrynus philippinicus	1
Langaw	Musca domestica	3
Grasshopper	Caelifera	3
Mosquito	Culicidae	3
Dragonflies	Anisoptera	2
Earthworms	Lumbricina	2
Bakassi	Scuticaria tigrina	1
Millipede	Diplopoda	1

TOTAL SCORE	26
NUMBER OF GROUPS	12
AVERAGE SCORE (miniSASS Score)	2.17

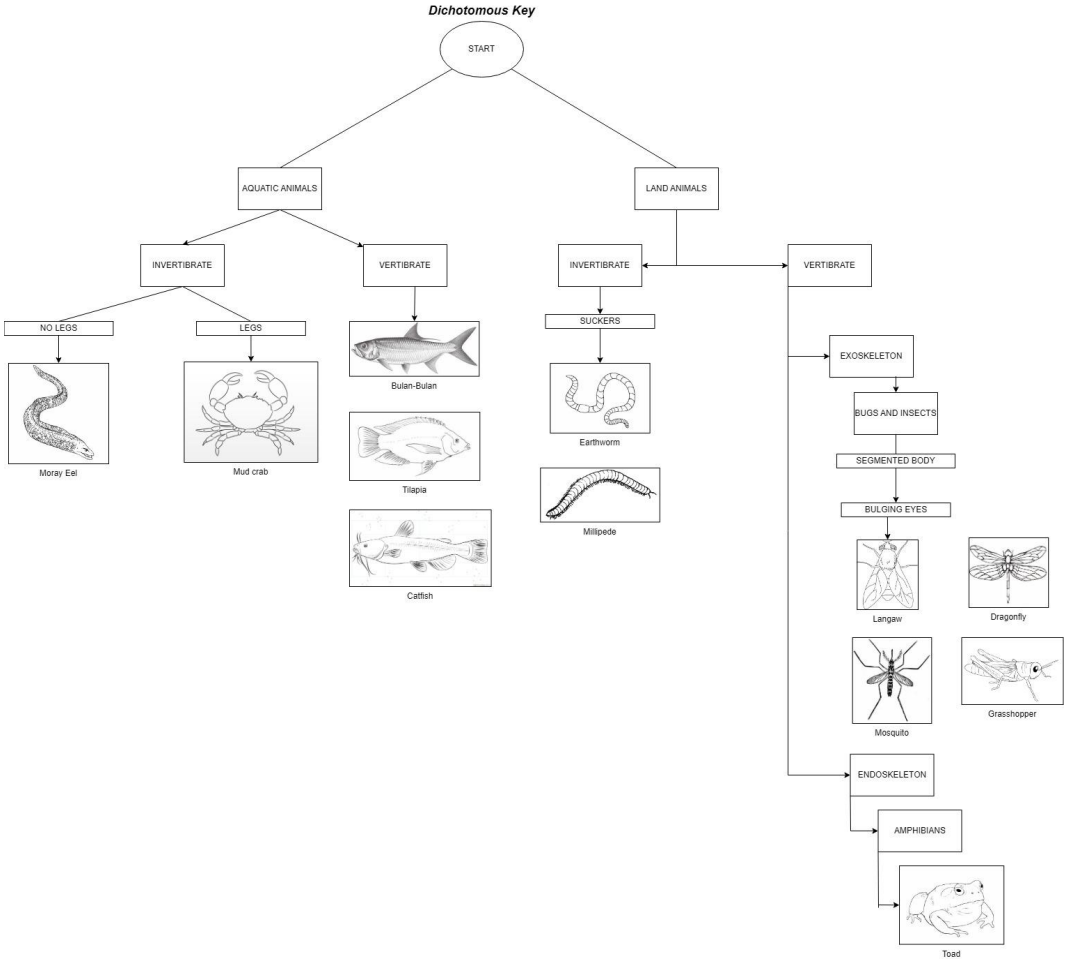

Figure 3. Ecology of the River.

Since the average miniSASS score is **< 5.3** therefore the ecological category of the river is in very poor condition (Critically modified - Purple).

River Stream Velocity

River stream velocity is the rate or speed at which water flows in a river or stream. Elements that influence it include the slope or gradient of the river bed, the amount of water moving through the river, and the shape and size of the river channel. Understanding river flow velocity is important for a number of reasons, including flood prediction, water management system design, and aquatic ecosystem health evaluation.

Table 7. Stream Velocity

TRIALS	MIDDLE OF THE RIVER		
	DISTANCE(m)	TIME(s)	VELOCITY(m/s)
1	50	152	0.328
2	50	120	0.333
3	50	125	0.40
4	50	145	0.344
5	50	160	0.3125
AVERAGE			0.3429

The average stream velocity of the five trials is 0.3429 m/s

Turbidity with Secchi Disk

Turbidity is one of the indicators that tells the quality of water in a body of water. It tells the transparency of water with the presence of suspended particulates (*Water treatment solutions*).To be able to determine the turbidity of the Butuanon River, a Secchi disk is used. Getting the depth wherein the Secchi disk disappeared and reappeared gives the researchers the idea of how murky or cloudy the water is and gives the researchers the turbidity of the water.

Table 8. Turbidity with Secchi disk.

TRIALS	DEPTH 1(cm) (Secchi disk disappeared)	DEPTH 2(cm) (Secchi disk reappeared)	AVERAGE DEPTH - SECCHI DEPTH(cm)
1	29.86	24.77	27.32
2	29.89	23.83	26.86
3	34.93	29.75	32.34

From the data collected, the researchers observed that the Butuanon River's water is murky and cloudy when it meets the eye. A total of 3 trials were conducted using the Secchi disk and the following average depths were obtained: 27.32 cm, 26.86 cm, and 32.34 cm. It can

be deduced that the Butuanon RIver has a low reading of depth from the Secchi disk which indicates that the water is murky.

CONCLUSIONS AND RECOMMENDATIONS

The gathered data shows that phosphate concentrations in downstream Butuanon river is 10 ppm which is higher than the normal range(0 to 0.1 ppm). This means that it will speed up eutrophication in rivers leading to water quality problems such as lowering down the dissolved oxygen levels which can cause fish kills and other aquatic life. On the other hand, the total hardness of water in the river is 425 ppm which is classified as very hard. According to the locals, the Butuanon river downstream area is prone to flooding during heavy rains and typhoons. However, in 2019 the City government of Mandaue performed dredging in the river to avoid the flooding; this will negatively affect the river's composition, diversity, and resiliency. Furthermore, dredging can alter the chemical properties of sediments causing the release of toxins and pollutants. The plastic pollution in the river is measured using the Randomized OSPAR Riverbank Monitoring data and Randomized OSPAR Floating Plastic Waste data. From the Randomized OSPAR Riverbank Monitoring data, It was found out that the highest percentage from the litter composition is plastic pieces greater than 50 cm in size (hard and soft) gaining a total of 62% from the total litter composition on the riverbank area. From the Randomized OSPAR Floating Plastic Waste data, It was found out that the river plastic waste category is C which means that it is polluted. The turbidity of water in the river was measured using Secchi disk and it was found out that the water is murky which means the presence of different suspended particulates is high.

In order to achieve the C class status for the downstream part of the Butuanon river the Phosphate levels in the river must be lowered significantly. In surface waters phosphates can cause major environmental problems. This is mainly due to their special role in the eutrophication of slowly flowing or standing waters. In natural waters, phosphate is a growth-limiting factor for the phytoplankton present. If the phosphate content rises too much the nutrient availability becomes so great that a so-called algal bloom can occur. The decomposition of dead algae consumes a lot of oxygen, which causes the concentration of oxygen to drop so much that many aquatic organisms die. The remains of these dead planktons and other aquatic organisms contribute heavily to the turbidity(e.g.murky) in the water. This in turn allows for less sunlight to reach the bottom of the river making photosynthesis much more difficult which also leads to lower oxygen levels at the bottom of the river where most of the decomposition of biomass takes place. This means that aerobic decomposition of biomass can no longer take place. Anaerobic bacteria take over, but at the same time produce toxic metabolic products such as ammonia in addition to methane. This is what causes the horrific smell and the black color of the river. Therefore, we recommend to the government of Cebu to significantly reduce the phosphate concentration in the river as well as lowering the phosphate concentrations in soil since this will eventually flow into the river as well. This can be done by either removing bottomless septic tanks and replacing them with traditional sewage or replacing them with more modern septic tanks that are more often dislodged. Our secondary recommendation is to strengthen the dykes around the downstream parts of the river. The current dykes are built from

plastic waste as well as substrate extracted from the bottom of the river last year. However due to the erosion of these dykes the plastics are starting to flow back into the river adding to the plastic soup problem in the oceans. We recommend strengthening the dykes by planting vegetation around the insides of the dyke. This will provide additional protection against the erosion of the dyke and the roots of the vegetation will strengthen the core of the dyke. This will also provide better opportunities for the ecology of the river to flourish.

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PRACTICAL SOLUTION

Design of the Solution

The design of the solution is to establish a river side halophyte filter wetland of tiger grass with the help of mangrove trees to regulate the flooding and act as a wetland protection. The researcher planned to widen the river side along the curve area of the river since velocity is higher in those areas. Landscaped the soil to form a gentle slope where two layers of vegetation were planted. The first layer of vegetation will be the mangroves which will be planted on the deeper water elevation a few meters away from the river shore. The second layer of vegetation which is the tiger grass will be planted on the shallow water and gentle slope area between the mangroves and the river shore. This sustainable method could resolve both flooding and filtering out chemical water pollutants, because of the combination effect of mangroves which will stabilize fast water current during high water discharge of the river and at the same time the tiger grass filtering out the heavy pollutants such as phosphates in the river and the soil.

Tiger grass is a species of grass that has gained attention for its potential use as a halophyte filter. Halophytes are plants that can grow in saline environments, and they are being studied as a sustainable solution for treating wastewater in coastal regions. In the case of the study the downstream Butuanon river is brackish to saline where tiger grass can potentially grow. Tiger grass has been found to be particularly effective at removing pollutants such as heavy metals and organic compounds from brackish and saline wastewater. The plant's high biomass production and fast growth rate make it a promising candidate for use in constructed wetlands or other phytoremediation systems. Furthermore, tiger grass has numerous other uses, including erosion control and as a source of fiber for weaving and paper production. The potential of tiger grass as a halophyte filter highlights the importance of utilizing natural resources in sustainable ways to address pressing environmental challenges. On the other hand, mangrove trees play a crucial role in mitigating the impact of flooding in rivers. These trees are known for their ability to absorb water and store it in their root systems, which helps to reduce the volume and velocity of water during heavy rainfall or flooding events. Additionally, mangroves act as a natural barrier against storm surges and tidal waves, providing protection to coastal communities from the destructive force of these natural disasters. Mangrove forests also serve as a habitat for numerous species of plants and animals, which contribute to the overall biodiversity of the ecosystem. Overall, the presence of mangrove trees in riverine areas not only helps to prevent flooding but also provides a range of ecological and social benefits.

Locational Analysis

The location of the downstream Butuanon river is presented in the following figure.

Within the area of the downstream Butuanon River assigned, there is a part of the stream that meanders sharply, increasing the flow velocity within that part of the river, and any particulate matter flowing within the river at that moment will have a higher chance of reaching the river wall in that area. The outside curve of the meander makes it a viable location to place the mangroves as most of the plastic waste and chemical pollutants will reach this area and be trapped or filtered by the mangroves.

Social Cost-Benefit Analysis Explanation

The costs of this project are the excavation of the river walls to a gentler slope, the planting of the mangroves, the continuous nurturing and overseeing of the mangroves (including pest control, cattle protection, etc.), and maintenance of cleaning the trapped plastic within the mangroves.

The benefits of this project, if it were to be successful is the decrease in pollution within the area which include: decrease in the chances in flooding because of fewer plastics blocking the stream, opportunities for resources with the increase in biodiversity resulting from the decrease in phosphate levels, more pleasant environment for residents and visitors because of the reduction of bad odor and clearer water color, and generates jobs from the continual collection of trapped plastic within the mangroves. The mature tambo plants can also be responsibly harvested and made into products to provide another source of income for the local community maintaining the area.

Planning

The outer curve of the river bend must first be surveyed in order to know how much soil must be excavated in order to achieve the desirable slope for the mangroves to be planted on since the current river wall is far too steep for the correct execution of the plan. The outer curve of the river bend is then excavated with the proper procedures (offsite disposal area) in order to avoid any outcomes of the excess soil tampering with the project in the future. This can be carried out by a construction company near the area.

The seeds of the tambo encased in biodegradable seed bags are then planted on the excavated outer bend. Biodegradable sandbags are also placed on the embankment of the slope in order to decrease the flow velocity needed for the proper growth of tiger grass. The seed bags and sandbags act as extra protection for the seeds in the event of a flood or storm where the flow velocity of the river is high, and are biodegradable to decrease plastic waste within the area. These activities can be carried out by volunteers or local community members.

The seeds are then nourished and overseen until the plants are fully matured and at a fully functional capacity of acting as a halophyte filter for the downstream portion of the river bend. This includes the implementation of fertilizer, the protection from pests and cattle, and the removal of dead roots and damaging material. Once the tambo is fully grown, the sand and seed bags have fully degraded and direct contact with the river flow can no longer damage the mangrove and the filtration of phosphate from the river water can now commence. Maintenance of the mangroves such as pests control and plastic waste removal must be prolonged for the health of the mangrove. These responsibilities can be carried out by community members along with a salary incentive from the LGU.

Stakeholders Involved

The stakeholder involved in this project are responsible for the overall success of the project: the reduction of chemical and micropollutants found within the Butuanon River

The highest priority stakeholder of this project are the groups assigned to the upstream areas of the Butuanon River since the success of this project heavily relies on the improvement of water quality from those areas. This project has the potential to improve water quality in the downstream parts of the Butuanon river but will be less effective if the river water is already heavily polluted once it has reached the downstream areas.

Another important stakeholder are the local residents because they are the proposed laborers responsible for the maintenance and operation of the tambo fields. The local residents will be assigned to collect the trapped plastic and garbage from the tambo fields and the continued oversight of the health of the tambo plants. This would have to be done on a regular basis unless the projects assigned in the upstream areas have been proven to be successful, then the workload for plastic removal will be reduced.

The Local Government Unit is another important stakeholder since they are responsible for the acceptance of an excavation permit for the widening of the river, and providing the cash incentives and other benefits for the local community members acting as laborers for the maintenance of the project for the foreseeable future.

Other stakeholders include the construction company assigned for the excavation of the river embankment, and the biodegradable sandbag and seedbag company for the protection of the tambo seedlings.

Operation Maintenance

The maintenance of the operation once the project has finished (the tambo plants have matured) include the continual oversight of the health of the tambo plants and its nearby environment. Pests that attack the health of the plant, cattle and other animals/vandals that trample or eat plants, and the quality of the soil must be constantly monitored in order for the tambo plants to be healthy and operate at maximum efficiency. The laborers to carry out this maintenance are to be the local community members who are willing to provide these services in exchange for a cash salary provided by the Local Government Unit (LGU).