



# Waterbenders' Solution for a Dead River

Group 8 – Bulacao River Downstream Portion

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## A. PREFACE

Cebu City is one of the biggest cities in the Philippines and as such also has many big problems. One of these problems is the Bulacao river. This river has suffered from contamination, both physically and chemically, for a very long time. Waste has built up beneath the river, resulting in ammonia and LAS being found in the water. The pollution has caused the downstream portion to be classified as a “dead river”, wherein flora and fauna are unable to flourish. There have been attempts to solve this problem, but none resolved it.

The Bulacao River which was once classified as class C river is now classified as class D which is its only purpose is for navigation due to the tremendous amount of pollution found in the river.

For that reason, a possible solution to this problem has been considered and is described in this report.

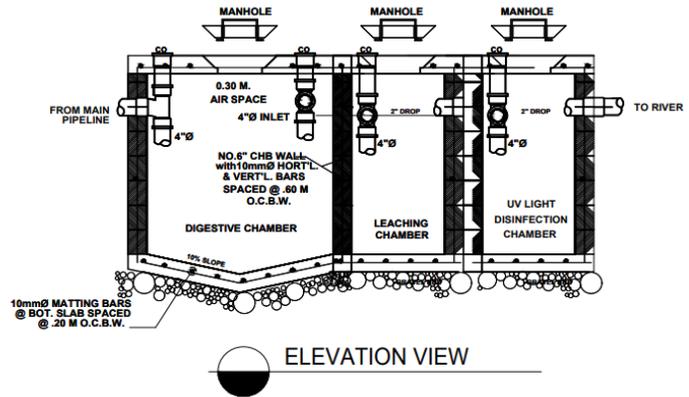
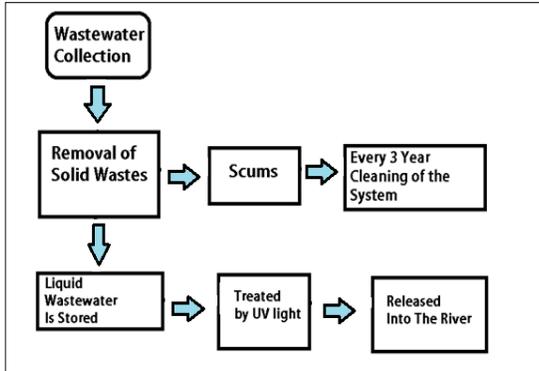
- a) design of the solution.
- b) Locational analysis. Where in the river should the solution be applied.
- c) cost benefit analysis with explanation.
- d) planning.
- e) stakeholders involved.
- f) operation and maintenance.

## B. PROJECT DESIGN

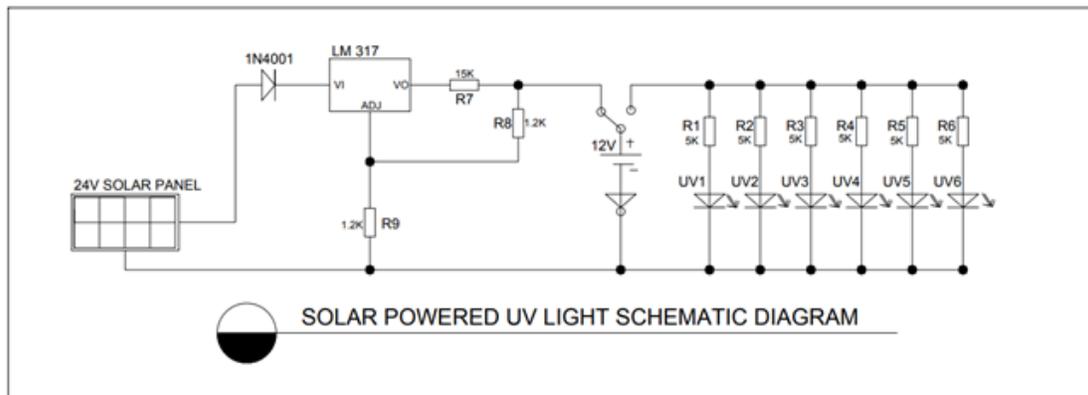
The project design mainly consists of three different chambers in filtering the water mainly: The Digestion, the Leaching and the UV disinfection chamber. The first step happens when the waste water enters into the first chamber in which the digestion chamber. In the digestion chamber, present bacteria indulge sludges and as a main result the solids present in the wastewater are reduced significantly. The next basin would be the leaching chamber. Mainly the leaching chamber controls the effluent discharge done by the septic tank allowing adequate natural wastewater treatment. Lastly the UV disinfection chamber; this chamber mainly focuses on targeting the present pollutants specifically the Fecal Coliform bacteria which is the greatest threat in this river. The whole process is powered via a solar panel system to make it automated as possible.

An ultraviolet disinfection transfers electromagnetic energy from mercury arc lamps to an organism's genetic material. When UV radiation penetrates the cell wall of an organism, it destroys the cell's ability to reproduce. This would mean the radiation from the ultraviolet inhibits the cell growth of the bacteria. Unlike sodium hypochlorite (liquid chlorine) disinfection, UV disinfection's equipment is straight-forward and simple to operate and as well as the maintenance and operating cost is significantly lower.

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As shown above, the design mainly utilizes concrete hollow blocks, steel and the pipes. As for the hollow blocks, a 6" concrete hollow block shall be used for the main wall of the structure. As for the pipes, standard Polyvinyl Chloride (PVC) Pipes are used both on the piping system upon connecting the pipes into the wastewater UV treatment system.



The electrical design of the proposed system is as shown above. Mainly a 24V (2x12v) Solar Panel is used in the main design. A 1N4001 Diode was utilized to ensure one way flow of current and the charging controller that was used is the LM 317 which is commonly used in solar powered electrical systems. Since, the current being discharged by the battery is a form of Alternating Current, an inverter was used to convert it into a Direct current by which the UV light can fully utilize. In cases of LED UV lights, an inverter is not needed.

## C. COST BENEFIT ANALYSIS OF THE SOLUTION

EARTHWORKS						
ITEM NO.		ITEM DESCRIPTIONS	QTY.	UNIT	UNIT COST	TOTAL
MAIN	SUB	EARTHWORKS			PHP	
1						
	1.1	CUT	400	cu.m.	100	40000.00
	1.1	FILL	0	cu.m.	100	
<b>SUB-TOTAL EARTHWORKS</b>						<b>40000.00</b>
STRUCTURAL WORKS						
ITEM NO.		ITEM DESCRIPTIONS	QTY.	UNIT	UNIT COST	TOTAL
MAIN	SUB				PHP	
4		MASONRY				
	4.1	CONCRETE HOLLOW BLOCKS	546	pc.	16	8736.00
	4.2	MORTAR				
	4.2a	PORTLAND CEMENT 40KG	78	bag	259	20202.00
	4.2b	SAND	20.5	cu.m.	1435	29418.00
4A		PLASTERING				
		PORTLAND CEMENT 40KG	48	bag	259	12432.00
		SAND	15.9	cu.m.	1435	22817.00
4B	4A.1	10mm dia. STEEL BARS	98	m	150	14700.00
<b>SUB-TOTAL STRUCTURAL CONCRETE</b>						<b>108304.00</b>
PLUMBING						
ITEM NO.		ITEM DESCRIPTIONS	QTY.	UNIT	UNIT COST	TOTAL
MAIN	SUB				PHP	
5		MATERIALS				
	5A	2" dia. PVC PIPE	70	m	50	3500.00
	5B	4" dia. PVC PIPE	30	m	60	1800.00



	5C	6" dia. PVC PIPE		15	m	70	1050.00
	5D	ASTM PIPE FITTINGS		50	pc.	50	2500.00
<b>SUB-TOTAL PLUMBING</b>							<b>8850.00</b>
<b>ELECTRICAL</b>							
ITEM NO.		ITEM DESCRIPTIONS		QTY.	UNIT	UNIT COST	TOTAL
MAIN	SUB					PHP	
5		MATERIALS					
	5A	3/8 WATTS UV LIGHT		6	pc.	1000	6000.00
	5B	LM 315 INVERTER		1	pc.	500	500.00
	5C	1N4001 DIODE		1	pc.	20	20.00
	5A	12 V SOLAR PANEL		2	pc.	7500	15000.00
	5B	1.5K RESISTOR		2	pc.	10	20.00
	5C	5K RESISTOR		6	pc.	30	180.00
	5D	15K RESISTOR		1	pc.	50	50.00
	5D	POWER INVERTER		1	pc.	1000	1000.00
	5A	12V BATTERY		1	m	1200	1200.00
	5B	8mm dia. TTHN AWG WIRE		28	m	150	4200.00
	5C	15mm. dia . RSC PIPE		5	pc.	100	500.00
<b>SUB-TOTAL ELECTRICAL</b>							<b>28670.00</b>
<b>GRAND TOTAL</b>							<b>185 824.00</b>

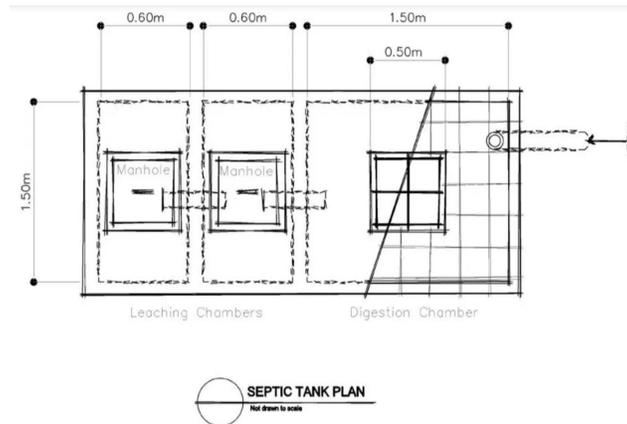
## ESTIMATED COST OF THE SOLUTION

The Figure above shows the detailed breakdown of the estimated capital cost of the said solution. It can be observed that the highest cost lies mainly on the structural works since its main structure is derived from the standard septic tank structure. Also, due to the fact that the type of soil found in the proposed location area is mainly Quaternary Alluvium thus, the structure was reinforced with additional steel. The lowest cost as shown is the plumbing works which involves the different kinds of pipes to be used. Because the chosen pipes are PVC pipes, it provides a far economical value thus, resulting in a low-cost total. As for the Electrical works, it can be observed that most of the materials used are not expensive as compared to the



## UV System vs. STP and Septic Tanks

As shown in the Cost estimate, the total cost of the said solution falls around 180-200,000 php. Although it is quite expensive at first glance, it can be observed that if it is compared to a construction of a typical Sewage Treatment Plant, it will cost way higher than the proposed solution. The budget for the Marikina Sewage Treatment Plant is 2.7 billion php that is designed to clean 100 million liters, this was 4 years ago and prices have changed which will cost around 4 billion PHP now. In a similar sense, the wastewater treatment facility is a much more economical way than the construction of septic tanks for all households due to the fact that most of the households residing and contributing to the pollution in the river are illegal settlers. According to philconprices, a simple septic tank plan shown below will cost an estimated 40-45,000 PHP per household.



## UV System vs. Chlorination System in Wastewater Treatment Facility

Comparing the costing of the said solution to the Chlorination system in a typical wastewater treatment facility, the use of UV lights especially if it is solar powered is a far more economical system as compared to the Chlorination of water to remove the Fecal Coliform Bacteria mainly because, the Chlorination involves a costly maintenance since it requires the waste water to be chlorinated almost every month. UV lights on the other hand only rely on the power given by the solar panel which does not consume any external electricity and its maintenance mainly revolves around the replacement of UV lights where its main lifespan lasts around 4-6 months

## Benefit of the Solution

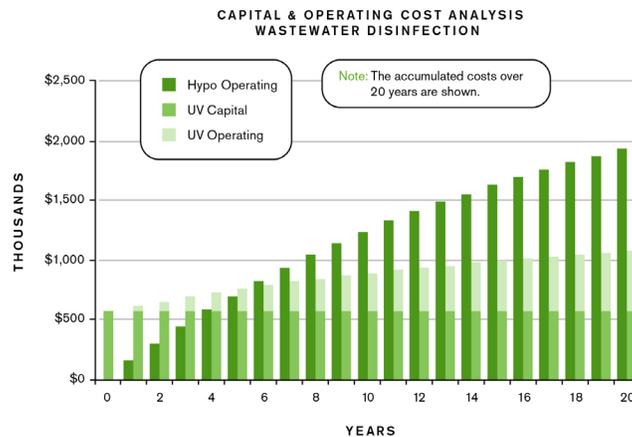
An estimated cost of 180-200,00 php will be a great investment, since the river passed the TSS, UV light will reach the target bacteria and stop it from replicating before going to the river. Compared to chlorination and STP, using UV lights is more economical since the main problem is total coliform count. Once the microorganisms in the water are exposed to UV light they will become inactive and can no longer replicate. This process will also be environmentally friendly compared to chlorine that will not only target bacteria but it will also change the taste of the water,



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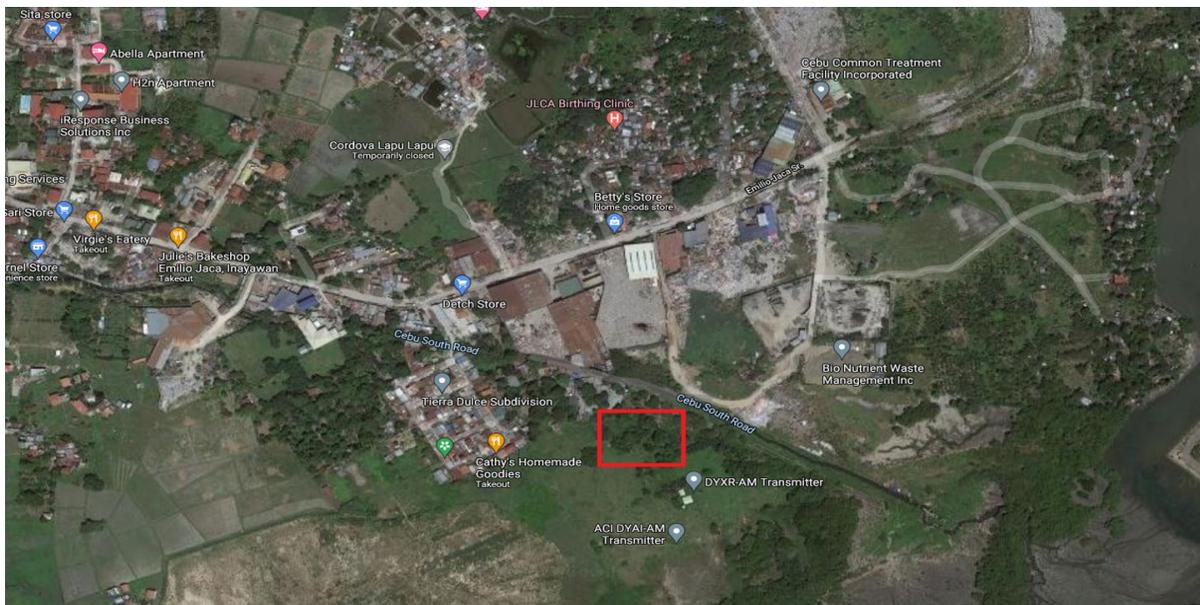
the smell and the pH that may contaminate the river. Maintenance for this facility will be the replacement of UV lights 2 to 3 times a year and light cleaning for solar panels every 2-3 months.

It can be seen in the chart below that although the capital cost of using a UV disinfection as treatment for wastewater, the cost of the UV facility system would provide a return on investment. If we compare this to the data for the chlorination facility system (Hypo Operating), its operating and maintenance cost would increase after a few years because of the cost of the chemicals.



## D. LOCATION OF THE SOLUTION

The location for the wastewater treatment facility will be located as part of the jurisdiction of Talisay City, specifically it will be located at Brgy. San Roque, Talisay City Cebu. This will be located near the end of the river where it connects to the sea. The map below shows the exact location of the possible facility which will cover about 70 sq.m. of land while following the 3m clear distance from the river.



The soil in the downstream portion of the river is noted to be Quaternary Alluvium (JICA pdf) . This type of soil is typically made up of a variety of materials, including but not limited to fine particles of silt and clay and larger particles of sand and gravel. The land that would be utilized by the solution is owned by the government.

## E. PLANNING AND IMPLEMENTATION

<p><b>Pre-implementation Process</b></p>	<p>As for the implementation and planning of the proposed solution. Since the main concept of the design is partially done, at this stage, should the government wish to pursue it the revisions of the designs that should be brought up so that the design could be revised. When the design is finalized, depending on which government would adopt the solution should proceed to the bidding process for the said project.</p>
<p><b>Implementation Process</b></p>	<p>Upon the implementation of the project, specifically the construction of the project the government agencies should be constantly active in monitoring the construction process to ensure that the said project could be completed both in punctuality and in good quality. When the project is already implemented, it is also important at this point to bring awareness to the people by showing and explaining the mechanism of the wastewater treatment facility. This might encourage illegal settlers to redirect most of their waste into the said facility which might result in a great reduction of Fecal Coliform Bacteria within the river.</p>
<p><b>Post-Implementation Process</b></p>	<p>After the implementation of the project, the local government should continue bringing awareness to the people by conducting seminars and utilizing the digital platform. The water quality of the river should also be tested regularly as to identify and give more inputs on the efficacy of the said facility</p>

## F. STAKEHOLDERS

For the solution project regarding the pipe system and the treatment plant it is important that the main stakeholders are being inventoried in an analysis. Before starting the project, this stakeholder analyses should be complete so that all different stakeholder interests and influences are inventoried. This analysis ensures that any potential problems with stakeholders are addressed at an early stage in the project. When a stakeholder disagrees with the project and feels like his or her interests weren't seriously taken into account the stakeholder can boycott or create support for a boycott for the project. That's why a good stakeholder analysis is very important for the smooth running of the project.

The following analyses is a quick scan of the main stakeholders involved. Their interests as well as their influences are marked with "+" and "-".

Stakeholder	Explanation	Interests	Influences
The Local Government of Cebu and Talisay	Because the Bulacao River is located in Cebu and Talisay it is important that they are actively taken into account in choices and constant contact is maintained. They want the very best for their citizens. Cleaning the river and providing a solution is a must for them	++	++
Metropolitan Cebu Water District (MCWD)	Since the Bulacao River is part of the service area of MCWD it is important that they are taken into account in choices and that constant contact is maintained. They want the very best for their customers and a dead river in their service area will diminish their image.	+	+
Department of environment & National Resources (DENR)	The Department is the primary agency responsible for the conservation, management, development, and proper use of the country's environment and natural resources. For this instance it is important that they are taken into account and be kept informed. They want a clean and healthy environment and don't want to see a class D river.	++	+
Department of public Works & Highways (DPWH)	The DPWH is mandated to undertake the planning of infrastructure, such as flood control and water resources projects, and the design, construction, and maintenance of bridges and flood control systems. Laying and connecting the pipes near the river and constructing a treatment plant near the river is why this stakeholder is important and needs to be taken into account and be kept informed.	+	+
Citizens	The citizens near the river want the river to be clean and attractive again. They do not want any weird constructions near their houses they don't know about. Therefore it is very important that the citizens are asked for their opinion and that they are constantly informed. If not and they don't like the project, they can boycott or create support to boycott the project	++	-
Barangay	Serving as the primary planning and implementing unit of government policies, plans, programs, projects, and activities in the community, and as a forum wherein the	++	+



	collective views of the people may be expressed and considered this stakeholder is important for the project.		
Private Corporations	Private corporations and companies near the river want the river to be clean and attractive. They do not want any weird constructions near their company they don't know about. Therefore it is very important that they are constantly informed.	+	-

## G. OPERATION AND MAINTENANCE

### Operation

The operation of the system is fairly simple. Since the said facility heavily relies on solar power, the facility can fully function during the day. And because the design has a battery installed in the system, the said facility can fully function during night time. The facility can also be turned off and on using a simple switch in case of maintenance.

The plan will be presented to the government of Cebu. At first it is logical for the government not to agree with the plan because informal settlers are basically getting a free sewage system while the rest of the city has to pay for their sewage system. On the other hand, the government could alternatively decide to take a different approach to clean the river of fecal coliforms, like for example treating the water at the mouth of the river. But this way, the informal settlers are still allowed to dump their fecal waste in the river and it comes down to the same thing.

Another way to remove fecal coliforms from the river is by moving the informal settlers to a different location. This concept was tried in a project in the past, unfortunately this didn't work out because of social challenges. Poor people in the Filipins don't have another place to live and end up as informal settlers so the problem continues to exist. (Schrestha, Tuladhar, & Zevenbergen, 2014)

Because the government is responsible for retaining a clean city, they will be certainly interested in this project. If the government agrees on the plan, they will be responsible for the construction of the sewage system. Also, the government can receive cooperation from the students who designed the sewage system.

### Maintenance

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The maintenance of the system mainly revolves around the daily monitoring of the UV light if they work or not. If the UV light runs out of power they can be easily replaced just like a typical light bulb. The switch can be turned off so that the replacement procedure would be safe.

The table shown below is the rough estimate cost of the maintenance of the said facility

MAINTENANCE	ASSUMED FREQUENCY	COSTS
UV Lights	Every 6 months	6000 php
Electrical Wirings	Every 6 months	2000 php
Cleaning of the Facility	Every 3 years	150000 php
Technical Issues (Pipe failures)	Every 6 months	3000 php
<b>Average Cost Per Year.</b>		<b>20 000 php</b>

It can be observed that the average cost per year falls around 20,000 php or at least 2000 php per month which is fairly low as compared to other water treatment facility mainly because the primary focus of this facility is to discharge wastewater that has lower Fecal Coliform count.

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