Kaanyag sa Kaugmaon

Constructed Wetlands for Waste Water Treatment

Group 6 hereby declares that the following document has been written by the respective team members and we take full responsibility for its content. We confirm that the text and the work presented in this document is original and that we have not used sources other than those mentioned in the text and in the references.

James Dudley-Owen
Leonard Borbon
Rachel Ann Castaneda
Peita Mae Jovero

Kaanyag sa Kaugmaon

Constructed Wetlands for Waste Water Treatment

Organization:	University of San Carlos
	Rotterdam University of Applied Science
Author:	James Dudley-Owen
	Leonard Borbon
	Rachel Ann Castaneda
	Peita Mae Jovero
Attendant:	Arnold Benedict Sab-a
Version:	1
Place & Date:	Mandaue, Philippines 20/11/2018
Illustration title page:	(Dudley-Owen, 2018)

PREFACE

Before you lies the advisory research and report "*Kaanyag sa Kaugmaon*" by River Chiefs Consultants. An investigation into current pollution levels and general state of the river. The conclusions and advice presented in this report are in line with respect to the wishes of the different stakeholders. This report has been written in the framework provided by the University of San Carlos (USC), Rotterdam University of Applied Science (RUAS) and Mandaue Community Environment and Natural Resources Office (MCENRO), so that the students of the USC and the RUAS may gain insight into the field of water management in a multi-disciplinary and multi-cultural team. The report and innovative solution proposed herein will be presented at the 4th International River Summit 2018 (IRS 2018).

This report has been written with great dedication from the 13th of November 2018 till the 20th of November 2018. River Chiefs would like to thank our colleagues for their feedback, the lectures and professors for their knowledge and understanding.

We hope you enjoy reading the report.

Mandaue, 20/11/2018, Group 6

TABLE OF CONTENTS

INTRODUCTION

The 23-km stretch of the Butuanon River used to be a big contributor to Cebu's agriculture and trade. But as the city evolved into a more industrialized and urbanized city over the past 30 years, the river suffered great setbacks with the growing population, lack of proper waste disposal and the discharging of industrial waste into the river. But with the efforts of the people who still believe that the river is not a hopeless cause, the river still has a fighting chance. In 2015 the river was considered 25% rehabilitated. Just this year, Mandaue City accepted the privilege of hosting the 4th International River Summit 2018 (IRS 2018) because the local government believes that this would be a great opportunity to raise awareness about the condition of the Butuanon river. The river's road to full recovery is still a long journey but it is great to see people show their dedication and willingness in saving the river.

The upstream area of the Butuanon river is still pristine and clean. But the quality of the river after a few kilometers is extremely polluted. This report analyses the pollution and general health of the river by measuring different parameters. It presents a practical innovative solution and interventions that can be implemented in the upstream area under the Canduman-Cabancalan bridge to clean up or prevent further polluting of the Butuanon river. To save the Butuanon River, the Mandaue City Government in partnership with Mandaue Community Environment and Natural Resources Office (MCENRO) will rehabilitate the river through the input of the students from University of San Carlos (USC) and the Rotterdam University of Applied Science (RUAS) during the upcoming IRS. The City of Mandaue declared November as the Butuanon River Month and November 22 as Butuanon River Day (Sunstar Phillipines, 2017).

Last November 12, 2018, MCENRO conducted a symposium that covered the activities and projects that help spread awareness of the condition of the river. Examples are the mangrove eco-park in Paknaan and the viewing deck along U.N. Avenue. The cooperation between the private sector, residents and the government are to be promoted by the publicity campaign "*Bayanihan sa Butuanon*" wherein the stakeholders can more closely work together in rehabilitating the river. The objectives named by MCENRO are "Raise Awareness, Raise Commitment, and Raise Resources".

This lead to the following question:

- How can the River Chiefs create a long-term vision for rehabilitation of the Butuanon while raising awareness, commitment and resources for and of the stakeholders?
- How can the public be engaged, and through what activities/programs can awareness about the Butuanon be raised?
- And how do we encourage the city of Mandaue to commit passionately to the management programs that may be introduced in the future?

The four consecutive days of direct collaboration by the USC and RUAS students doing fieldwork, chemical and biological tests in the Butuanon river basin then analyzing the results, has provided the River Chiefs consultants with insight to the possible causes and the underlying problems of the river. The verdict is that the City of Mandaue lacks, basic waste management, wastewater treatment, and adaptive river management. Although legislation is in place to curb the discharge and dumping in and around the Butuanon the means to enforce the rules and regulations is lacking. Upon identifying the problem, the group has come up with various solutions to address the problem and to answer the questions in our research. To raise awareness, we must engage the youth as early as possible to increase knowledge about the state of the river, teach them about proper waste disposal practices and to teach about the consequences of rampant polluting. Awareness must be spread in schools so that the younger generation will be advocates of a better environment as they grow to maturity. In management studies it has been proven that people more readily adopt a goal and achieve it when it is linked to a reward (Daft, 2010). In other words, it is good to generate income while coincidentally rehabilitating the river. River Chiefs propose the building of urban wetlands for the treatment of wastewater and improving the resilience and adaptability of the Butuanon. Constructed urban wetlands (CUWs) are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and the associated microbial assemblages to assist in treating wastewaters. They are designed to take advantage of many of the same processes that occur in natural wetlands but do so within a more controlled environment. CUWs for wastewater treatment may be classified according to the life form of the dominating macrophyte [1], into systems with free-floating, floating leaved, rooted emergent and submerged macrophytes. Further division could be made according to the wetland hydrology (free water surface and subsurface systems) and subsurface flow CUWs could be classified according to the flow direction (horizontal and vertical) (Vymazal, 2010). The treated water can then be used by the residents for various purposes such as local car and clothing wash stations. The residents can then use this to generate income. The treated water can also be used to water plants and other cleaning purposes. The CUWs can be implemented by industrial and/or agricultural commercial enterprises to sustainably reuse their water. Not only can you earn from it, you can also save water.

The urban wetlands proposed is composed of gravel or rock beds sealed by an impermeable layer and planted with marsh plants preferably Phragmites Australis (common reed). The wastewater is fed at the inlet and flows through the porous medium under the surface of the bed in a vertical path until it reaches the outlet zone, where it is collected and discharged. In the filtration beds, pollution is removed by microbial degradation and chemical and physical processes in a network of aerobic[2], anoxic[3], anaerobic zones with aerobic zones being restricted to the areas adjacent to roots where oxygen leaks to the substrate (Vymazal, 2010). A helophyte filter system already exists in the Philippines today in Davao, the layers used are fine sand with a diameter of 0.15 to 0.3 mm, pulverized limestone, coconut fiber and gravel. This filter system is proven to be cost-effective and is biodegradable for 20-30 years.

[1] a plant, especially an aquatic plant, large enough to be seen by the naked eye
[2] relating to, involving, or requiring free oxygen
[3] relating to, involving without oxygen

MATERIALS & METHODS

This chapter describes the methods with which qualitative data was acquired and the materials used for the research.

SITE DESCRIPTION

The study was conducted in the upstream area of the Butuanon River, on the borders of Barangay Cabancalan and Barangay Canduman, Mandaue City, Cebu, Philippines. The site was below the Canduman-Cabancalan bridge. An android application (Measure Map) was used to take the coordinates and elevation of the area.

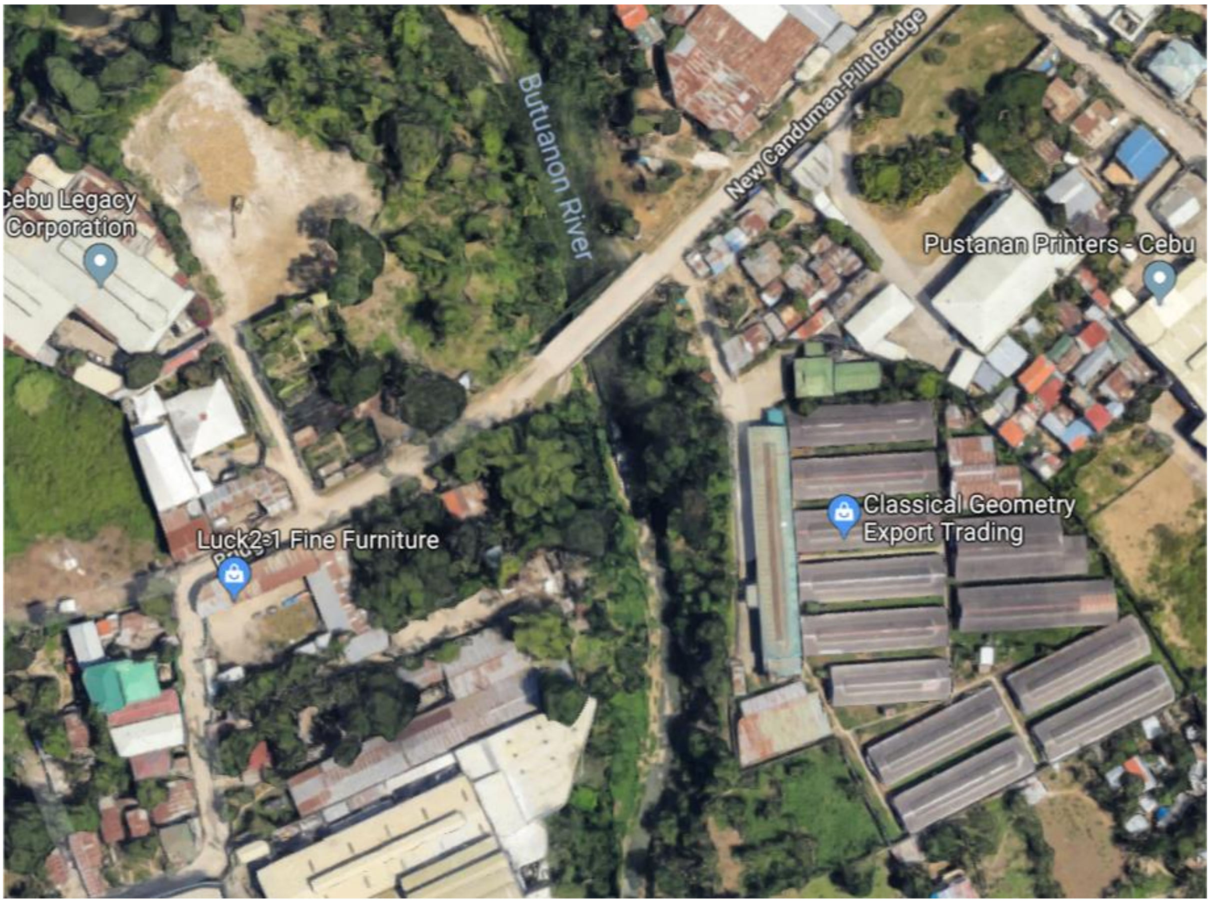

Image 1 Research area Canduman-Cabancalan bridge

QUALITATIVE PARAMETERS

Different parameters were tested to determine the quality and status of the river as well as its surrounding environment. The various parameter served as the basis for the construction of appropriate solutions that will efficiently solve the problems in the area.

RIVER WIDTH

The river width was measured using two methods: manual measurement and phone application (app) measurement. The manual measurement was taken by measuring from the opposite embankments using a steel measuring tape. For the phone app measurement, an app called Smart Measurement was downloaded from Play Store on an android device.

FLOW MEASUREMENTS

The depth at different points were measured along with the manual measurement of the width. After obtaining the depth and width of the river, a profile was created which helped determine the cross-sectional area of the river.

RIVER STREAM VELOCITY

A twig was thrown on the river which was used as a floating material to measure the time (in seconds) as it passed by a 3-meter length along the riverbank.

MAXIMUM FLOOD HEIGHT

Different residents living near the river were asked to describe the flood height of the river taking natural disasters like typhoons and tropical storms into consideration. An approximate measurement was then taken using a transect line from the bridge up to the water level.

URBAN WATER QUALITY

The water quality parameters tested were phosphate, nitrate, total iron, pH, dissolved oxygen (DO) and electrical conductivity. Each parameter, namely phosphate, nitrate, total iron and pH, have corresponding bottles which contained strips which were used to dip into a water sample from the river. These bottles had color patterns with scores of measurements which determine the value of the parameters.

A CTD diver was used to measure the pressure and electrical conductivity by dipping it into the water. With the help of the android app Akvo Caddisfly, the result was obtained. For the dissolved oxygen, an DO meter was used. This meter was turned on from the inside, making sure the lid was tightly closed to prevent the water from penetrating the seal. The DO meter was then slowly submerged in the water and timed (2 mins and 30 secs). The results were taken by connecting it to a phone/laptop device and downloading the data.

TURBIDITY

The turbidity was measured in two ways: using the Secchi disk and a phone application (app) called Hydro Color. In using the Secchi disk, it was slowly lowered into the water until the pattern of alternating colors of black and white was no longer visible and then the depth was recorded. The disk was slowly raised until it became visible and the depth was again recorded. This was repeated for a few more trials. The turbidity was then determined by averaging the 2 depths taken. In using the Hydro Color app an instruction was given after it was downloaded.

ECOLOGY OF THE RIVER

In determining the ecology of the river, a mini-SASS method was used which is a method of monitoring the health of the river by considering the sensitivity of various animals. Materials such as nets, sieves, and containers were used to capture and identify the different species found around the river. It was tabulated in the factsheet provide from the mini-SASS.

MATERIALS & METHODS

RIVERINE PLASTIC WASTE POLLUTION

In identifying different litter plastic along the riverbanks, a randomized OSPAR method was used. Ten random point areas with 1x1 (meter) quadrat parallel to the water line were established. The plastics found were categorized based from an OSPAR guide and recorded in an OSPAR form.

INNOVATIVE PLAN

The innovative plan was a series of plans formulated based from the qualitative data acquired from field sampling, from the seminars conducted and plans proposed by the members of Mandaue City Environment and Natural Resource Office (MCENRO). All the data gathered were analyzed which helped in reaching a series of solutions to answer the questions and problems pointed out in the study and the in the solutions, the innovative solution, was greatly highlighted.

RESULTS

Eight parameters were tested for the qualitative information of the river. Table 1 shows the list of annexes where all the figures, graphs and images are compiled.

REFERENCE	PAGE NUMBER
Annex A Flow measurement	XIX
Annex B Maximum Flood heights	XXV
Annex C Picture gallery of Butuanon River	XXVI
Annex D River width use Smart measure app	XXXV
Annex E Urban Water Quality	XXXVI
Annex F Riverine Plastic Waste Pollution	XL
Annex G Ecology of the river	XLI
Annex H River stream velocity	XLII
Annex I Turbidity with Hydro color & Secchi Disk	XLIII
Annex J PM-tool	XLIV

Table 1 Reference to the different parameters tested with corresponding graphs, analysis and descriptions.

FLOW MEASUREMENTS

The following method used in surveying a typical profile of a river channel with geometric shapes (I.e. triangles, trapezoid, etc.). Since the river was of short span and stretch, intervals were shortened, and different locations were determined to solve for a mean cross-sectional area. There were two values computed for the discharge; before and after the light rain. Since the intensity of the rain observed was small, larger values for the discharge is to be expected. At the very least, a total of 0.29 m^3/s of river discharge, carrying with it the pollution, was to be expected every day.

Pressure is a function of depth, and it is usually used as a means of measurement. As seen in the graph, as the pressure increases so as the temperature and the depth. Depth and pressure are directly proportional to one another. So as the depth increases, the pressure also increases. Temperature is also directly proportional to both the depth and pressure (Figure 7).

MAXIMUN FLOOD HEIGHT

An approximation of the maximum flood heights described by the locals were determined with the use of measuring tapes. The pictures taken were the places the maximum flood height had reached during the typhoon Yolanda which was about 5 to 6 meters. Residents also indicated that during average rainfall, the water level does not reach the ground level - about 1.5 to 2 meters - as seen in Image 4. The purpose of determining the maximum flood height was to know at which level the river can carry the garbage or wastes downstream and for the reference of the high-water level mark in the third (3rd) method of OSPAR monitoring; high water level mark monitoring. Image 3 showed the Canduman-Cabancalan bridge as viewed from below. During mega typhoons the water level rises to touch the undersides of the concrete construction of the bridge. That is a total of 8.5 meters from the water's surface as measured on Thursday 15th of November at 11:45.

RESULTS

RIVER WIDTH

There river in the upstream area, under the Canduman-Cabancalan bridge has varying widths with many protruding rocks at the middle and sides. This led to large variations in the velocity of the river, so a location with little obstacles and almost the same width was chosen.

The width, which was measured manually and using the app, yielded results that were close to each other thus, the data gathered manually was retained. The measurement locations were represented by section 1-3 (Table 4) and a visual representation of the measurement location depicted in Image 14.

URBAN WATER QUALITY

Table 7 showed results taken from the Butuan river on the 14th of November 2018. Unfortunately using the Akvo Caddisfly app for testing the water quality of the river proved unsuccessful. Therefore, the information needed was acquired using Hach test strips. The dissolved oxygen (DO) meter and data logger provided the remaining information. The values measured for the electrical conductivity was within range for the typical values of a river system (Class D water). Electrical conductivity is directly linked to salinity. Conductivity, specific conductance, is one of the most useful and commonly measured water quality parameters. In addition to being the basis of most salinity and total dissolved solids calculations, conductivity is an early indicator of change in a water system. Significant change, whether it is due to natural flooding, evaporation or man-made pollution can be very detrimental to water quality (Fondriest Environmental, Inc., 2014).

Conductivity and salinity have a strong correlation. As conductivity is easier to measure, it is used in algorithms estimating salinity and total dissolved solids (TDS), both of which affect water quality and aquatic life (Fondriest Environmental, Inc., 2014).

The electrical conductivity exceeds the limit that can sustain diverse aquatic life which is 500 µS/cm. Based on these findings it can be expected that little to no aquatic fauna can be found along this part of the Butuanon river. Table 9 shows the correlation between temperature, depth and oxygen levels. This was further illustrated by Figure 9. The more aerated water at the surface has a higher oxygen level as can be expected. The underlying water column has no direct contact with the oxygen rich air and therefore the findings of DO levels measured in section 1 aren't representative of the water quality. According to Gay-Lussac's Law (Helmenstine, 2017) temperature and pressure are directly proportional to each other. This means that as the pressure increases, the temperature increases. This explains why initially the water temperature rises thus decreasing the oxygen levels.

Using the Hach test strips iron, phosphorus, pH, nitrate and nitrite can be determined. The strips indicate that there were low concentrations of iron found in the water (Table 10). The pH level of the river was 8-9 which was comparable to ocean water. The optimum pH for river water is around 7.4. A pH level of 8.0 can sustain most river life except for mussels, clam and snails. Phosphate levels reached the highest with a range of 5-15. This range was higher than that of the Pasig river (B. Gorme, 2010)

RESULTS

As for the dissolved oxygen values, it can be affected by three factors: salinity, pressure and temperature. Temperature mainly affects the amount of oxygen dissolved since it interferes with the reaction of particles in the water. The three lowest points on the graph were the points in which the data logger was submerged in the river.

Excessive amounts of nitrate or nitrite in water can cause infant death, adult illness, and produce spontaneous abortion in cows. When water contains high nitrate levels, nitrites often are present in low concentration (Hach, 2018). Due to the severely polluted state of the Butuanon river, one could expect to find high concentrations of nitrate. However, the concentrations measured do not reflect that hypothesis. Considering that the test location was adjacent to the sewer discharge point of a poultry farm, many other production facilities and residential areas the conclusion must be that the gathered date is faulty. As to where the fault lies, possibly the strips were damaged during transit or the measurements were done incorrectly. Consequently, no conclusion of any merit can be made from the data.

Due to a lack of data no real conclusions as to the quality of the river water can be made. Therefore, a qualitative research had been done. The information presented by CNU Journal of Higher Education named.

RIVERINE PLASTIC WASTE POLLUTION

There are supposedly three methods of OSPAR monitoring to be tested and validated - namely: standard, randomized, and high-water level mark - but due to the characteristic of the riverbank having wild vegetation at its steep slopes and having inaccessible riverbanks, only the randomized OSPAR riverbank monitoring was carried out.

The purpose of this method is to determine the amount of persistent wastes that are discharged into the oceans daily, weekly, monthly, and so on. The main concern for this is the ingestion of these wastes to marine animals which is an example of how the food chain is disrupted (Table 13).

ECOLOGY OF THE RIVER

The mini-SASS (Annex **G** Ecology of the river) is a tool to monitor the health of the river by considering the sensitivity of various animals to the water quality and based on the average score of the river, it was deemed to be in good condition. The outcome of the classification of the river was doubtful at best since the river waters were murky in some parts and there were two channels of effluent from establishments and the residents. However, a quick look from about 300 meters north of the bridge, there were residents that were fishing at the middle of the river and they caught fish - tilapia being one of them.

From this, the river can be classified as healthy. Also, the factor that greatly affected the score of the mini-SASS, the stoneflies, are mostly found in small, cool, shaded streams with high dissolved oxygen and is one of the three most commonly used indicators in determining the health of an aquatic ecosystem (Voshell, 2002, p. 442). All in all, the color or smell of the river alone is not an indication of the current health of the river. The plants and the animals living in the river was one factor that described the general quality of the water in the river since the water helps in the growth of both.

RESULTS

RIVER STREAM VELOCITY

The stretch of the river concerned was about 7 meters, both ends have protruding rocks that affected the uniformity of the velocity along the profile of the river. About 3 to 4 meters of the right side of the river, facing north, was exposed, an indication of a continuous decrease in water level in the past years. Vegetation was abundant along the steep riverbank. Clear blue skies were observed as well as high temperatures. Velocity alone was not enough to determine any parameter in the river that the study required. The importance of measuring the velocity of the river was to get the discharge, which in turn can be related to the amount of pollution the river discharges into the ocean. The results (Table 16 Upstream group6 river stream velocity measurements Nov. 13, 2018Table 16 and Table 17) showed the velocities of the river during the absence and presence of rainfall. The rain experienced (November 14, 2018) was light which lasted for less than an hour. From this, a significant increase in the discharge was expected from average to heavy downpour.

TURBIDITY

Turbidity is an optical determination of water clarity. It is also an indicator of water quality based on clarity and the total suspended solids in the water. Also, clearer waters do not necessarily indicate that the river is healthy. In shallow waters, the use of Secchi disk is practical since it is cheaper, and the size used can be small.

From the data (Table 18), the Secchi depth was taken by calculating the average of the two measurements which was 42.5cm. This was taken after a light rainfall, so erosion was greater compared to the normal days. Also, only one trial was procured since the same results were obtained as determined by three persons.

Turbidity was also measured with an app called Hydro color. Inconsistencies may result in the handling of the equipment but nonetheless, an approximation of the turbidity of the river was enough to classify the state of pollution in the river. The suspended particles were, after conversion, about 8-18 mg/L and the turbidity was considered cloudy between 5 to 55 NTU.

CONCLUSIONS & RECOMMENDATIONS

Based for the results that were gathered for the qualitative parameters and the observations made around the site, the innovative plan was formulated. The innovative plan centers around a series of solutions, which answers the sub-questions, that will answer the main problem and the proposition of the innovative solution. First point of action of the innovative plan was to introduce an educational program (either workshops, school activities, seminars, outreach programs) that centers around raising awareness about the environment of Mandaue City, specifically towards the Butuanon River. The significance of this is that educational institutions cultivate the minds and discipline of the younger generation thus it is much easier to reach out and to teach them into growing up to respectable and responsible adults. As the saying goes "Ang Kabataan ay ang Pag-Asa ng Bayan" which roughly translates to "the younger generation is the hope and future of the country". The younger generation will continue the hope of raising awareness and committing to the work laid out thus it is important to reach out to these young minds. However, the drawback of this solution is that it will be difficult to cultivate such dedication and attention with the younger generation, furthermore the time before the younger generation can influence policy and practice is long. Also, since school curriculum have changed, it will be more difficult to include such activities. Because of that, it is also important to create technical solution besides long-term plans, thus the introduction of the innovative solution, Constructed Wetlands for waste water treatment.

Butuanon River is surrounded by different establishments and residential housing and with an aged and inadequate sewage system, most waste discharge runs off into the river. However, since the Butuanon river pollution is one of the many problems Mandaue City faces, expensive wastewater treatment facilities cannot be installed at the many locations around the river. River Chiefs therefore recommends the construction of Urban Wetlands for waste water treatment and climate adaptability. The urban wetlands treat wastewater using wetland plants which was first experimented by Käthe Seidel in Germany in the early 1950's. Since the many different type of wastewater has been treated as seen in Table 2 below.

Type of wastewater	Location	Ref.
Animal Waste	U.S.	[16-18]
Dairy pasture runoff	New Zealand	[19]
Agricultural drainage	U.S.	[20]
Storm water runoff-residential	Australia	[21]
Storm water runoff-highway	United Kingdom	[22]
Storm water runoff-airport	Sweden	[23]
Acid coal mine drainage	U.S., Spain	[24,25]
Metal ores mine drainage	Germany, Ireland, Canada	[26-28]
Refinery process waters	U.S., Hungary	[29,30]
Paper and pulp wastewaters	U.S.	[31]
Shrimp aquaculture	U.S.	[32]
Landfill leachate	Sweden, Norway, U.S.	[33-35]
Sugar factory	Kenya	[36]
Olive mill	Greece	[37]
Wood waste leachate	Canada	[38]
Metallurgic industry	Argentina	[30,40]

Table 2 Examples of the use of CWs for various types of seawater ***(Vymazal, 2010)***

As per study by Vymazal (2010), the construction of wetlands for wastewater treatment has been widely used from European countries to the US and Australia. The rapid urbanization and congestion in these areas is what prompted it to be called "urban wetlands". As a pilot project, this was proposed due to its cost-effectiveness, efficiency and sustainability. So, what is the value of importance of these urban wetlands? According to Water and River Commission of the government of Australia, it provides natural values like improving biodiversity, vegetation and habitat which was greatly damaged during anthropogenic activities. It also provides natural flood management since it can serves as storage during peak floodwater flows by enabling the water to disperse over the floodplain which reduces downstream flood levels and thereby reduces the impact of flooding (Water and River Commissions, 2001). The successful establishment of urban wetland can provide cultural and aesthetic services which can be used as a means of income and job source for locals. Its establishment also creates a greater chance for water filtration which increases water supply that can help the community's industrial and household consumption. The wetland can also serve as an educational and recreational activity for the younger generations as well as series of groups and organizations. But most importantly, this project is not only cost-effective, it is also sustainable and efficient. It might be high cost and at first glance, but past studies have proven and tested its efficiency and its lasting effect, and this was primarily a study and plan introduced to be the low-budget solution for wastewater treatment. The urban wetland can raise the attention of the citizens since it's a different type of work which is not wide spread in the Philippines and the maintenance of this project will generate commitment from the community, but not only that, the urban wetland acts as a filtration and water treatment system which purifies water, which in turn can be reused by the establishments around the area and generate more income. This income can then be used to manage and preserve the area which is a solution for the commitment of the citizens to maintain the cleanliness of the river. What's more, since this will be established in the upstream area, it can help lessen waste discharge that will flow down to midstream and downstream which can contribute to easier management of those areas and easier application of other solutions proposed by other groups. Laws and policies for governing wetlands have also been established all around the world as presented in the case study of Hettiarachchi *et al.* (2014). This shows the efficiency of the establishment of the wetlands as well as the commitment of the government and community to protect and properly manage and maintain these wetlands (M. Hettiarachchi, 2014).

The design by River Chiefs calls for a 15m^3 settling tank (Image 2 right) connected to a 10m^2 helophyte filter system. Placed on the South-Eastern bank as seen from the Canduman-Cabancalan bridge (Image 2 left).

Image 2 Right constructed urban wetland site location, left settling tank with 2 manholes

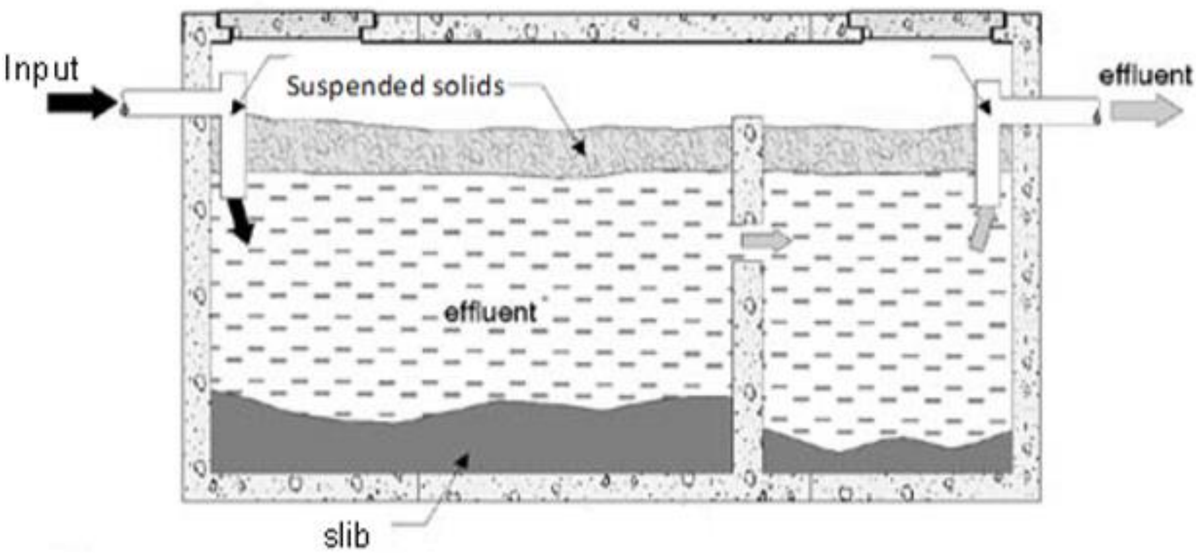

Figure 1 Schematic representation of a settling tank

As shown in Figure 1 the settling tank has a partition wall to allow for settling of suspended solids. Once the larger particles have settled the cleaner water can naturally flow to the helophyte filter through the innovative use of gravity. Once the water has exited the tank at location 1 the water continues its journey to the filter at location 2 the water flows vertically through the flow field toward the Clean water (Control) pit at location 3. At this point the water is tested for chemical and biological trace elements, when it is deemed clean enough for the intended purpose i.e. for commercial reuse, residential use, discharge into the river or drinking water, it may pass.

CONSTRUCTED URBAN WETLAND CONFIGURATION

1. Septic tank
2. Helophyte filter system
3. Clean water tank
4. Butuanon river

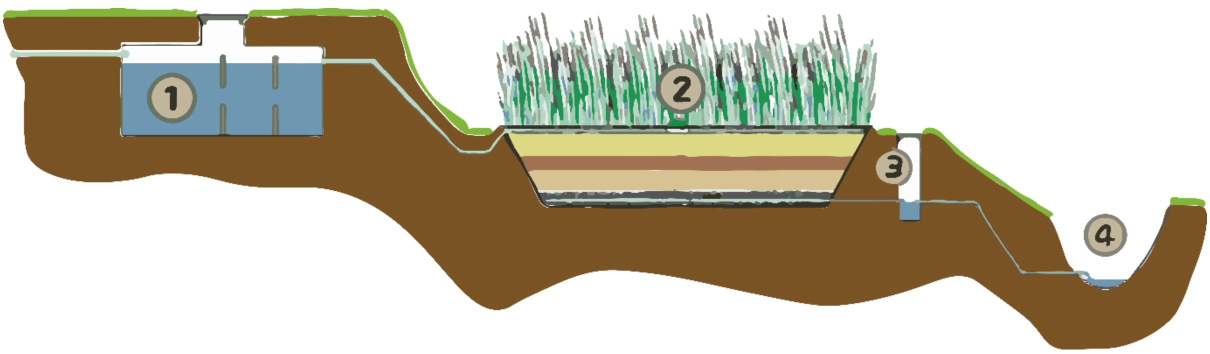

Figure 2 Stepped helophyte filter with natural decline

The plant to be used can be a common reed, Phragmites Australis, or the plant which MCENRO planned to use, vetiver (*Chrysopogon Zizanioides*). The design primarily focused on the poultry production farm in the upstream area. This will serve as a pilot program to estimate the costs, feasibility and amount of community awareness and participation the establishment of multiple urban wetlands along the Butuanon river.

The innovative plan is a series of solutions and phases, the so-called "Phased Approach". The solutions as discussed above are considered a pilot project and will kick-off the project with phase 1. After successful implementation and proof of concept River Chiefs recommend introducing the rest of the phases of the innovative plan to fully roll out the project throughout the Butuanon river basin. Phase 2 and 3 focuses on community involvement and upscaling. Since the focus of phase 1 is on establishing proof of concept, phase 2 and 3 involves various establishments that discharges their wastewater into the sewer pipe near the river, involving local businesses and incentivizing wastewater treatment. Increasing the scope and design of the urban wetlands will increase the clean water supply to the river which can then be reused by the stakeholders in the area as well as to create more business opportunities, generating income to help maintain the wetlands. Phase 4 then focuses on the expansion of the wetland to other parts of the river (midstream and downstream) as well as incorporating the other IRS 2018 student "innovative" solutions such as floating wetlands and plastic catching arms. Phase 5 would focus on establishing the urban wetlands to other bodies of water in Mandaue City.

At first glance, everything would be difficult, expensive and time consuming however nothing will happen if no one will take the first step. To raise awareness, to raise commitment and to raise resources, efforts from the community as well as the government should be united to fulfill these objectives.

EPILOGUE

The concept of urban wetlands has been around since 1950's. However, we often do not qualitatively compare the data collection with practical implementation, we prefer to explicitly express our ideas about how similar or dissimilar we judge them to be. River Chiefs has provided a means regarding this, to distinguish different degrees of commitment, awareness, and raise resources. The most important step in the scientific enterprise is shifting from a purely mental exercise to actual experimentation. Instead of reasoning about possible causes and relations in the natural world, the proposed innovative solution provides a real-world application for urban wetlands in the Butuanon river basin for wastewater treatment.

The Butuanon has a long and checkered past with pollution. The river has a history with varying degrees of successful rehabilitation. As of 2018 the river is classified as 25% rehabilitated. River Chiefs has researched the successes of the past and analyzed the failures. Learning from past endeavors has led to a comprehensive study in which several parameters of the river have been cataloged and compared to estimate the level of contamination. If nothing is done the river condition will deteriorate and possibly convert to an open sewer. This must not and cannot be allowed to come to pass.

The future is looking bright. Thanks to the innovative solution proposed by River Chiefs provides hope for the future and a cost effective long-term solution for the here and now. Using the Five Phased approach the project can be rolled out throughout the Butuanon river basin and beyond. Investing in the future is always worthwhile and will prove to be an investment with lasting returns, for this generation and those to come.

REFERENCED LITERATURE

4th International River Summit. (2018, september 14). *The Butuanon River: A Brief History*. Retrieved from 4th International River Summit: http://4thinternationalriversummit.org/the-butuanon-river-a-brief-history/

B. Gorme, J. &.-R.-H. (2010). *The Water Quality of the Pasig River in the City of Manila, Philippines: Current Status, Management and Future Recovery.* Environmental Engineering Research, Philippines.

CNU Journal of Higher Education. (2012). *Impacts of Waste Disposal Practices and Water Utilization of Riverside Dwellers on Physicochemical and Microbiological Properties of Butuanon River, Central Visayas.* Cebu City: ResearchGate. Retrieved november 19, 2018

Daft, R. L. (2010). *Management.* Mason, Ohio: South-Western Cengage Learning.

Dudley-Owen, J. (2018). Butuanon river near Cabancalan bridge. *Butuanon River Scan 2018.* Rotterdam University of Applied Science, Mandaue, Phillipines.

Fondriest Environmental, Inc. (2014, March 3). *Fundamentals of environmental science*. Retrieved from Conductivity, Salinity & Total Dissolved Solids: http://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/

Hach. (2018, November 19). *Nitrate and Nitrite Test Strips*. Retrieved from Hach: https://www.hach.com/nitrate-and-nitrite-test-strips/product?id=7640211606&callback=qs

Helmenstine, A. (2017, April 17). *Gay-Lussac's Law Definition (Chemistry)*. Retrieved from ThoughtCo.: https://www.thoughtco.com/definition-of-gay-lussacs-law-605162

M. Hettiarachchi, C. M. (2014). *Governing the urban wetlands: a multiple case study of policy, institutions and reference points.* Sri Lanka: Foundation for Environmental Conservation.

Rietland bvba. (2011). *Dossier Waterzuivering & Hergebruik.* Belgium: Rietland bvba.

Sunstar Phillipines. (2017, September 12). *Mandaue to save Butuanon river.* Retrieved from SunStar Phillipines: https://www.sunstar.com.ph/article/163597

Voshell, J. R. (2002). *Freshwater Invertebrates of North America.* Blacksburg (VA): The McDonald & Woodward Publishing Company.

Vymazal, J. (2010). *Constructed Wetlands for Wastewater Treatment.* Czech University of Life Sciences, Faculty of Environmental Sciences. Prague, Czech Republic: Water. Retrieved November 19, 2018

Water and River Commissions. (2001). *Government of Western Austrailia*. Retrieved November 19, 2018, from Water Facts: https://www.water.wa.gov.au/__data/assets/pdf_file/0016/5380/11420.pdf

ANNEX A FLOW MEASUREMENT

To determine the discharge of the river, velocity and the cross-section of an area should first be calculated.

Distance (m)	Time (s)	Velocity (m/s)
3	13.47	0.22
3	19.01	0.16
3	22.88	0.13
3	12.03	0.25
3	23.12	0.13
3	12.88	0.23
Average =	17.23	0.19

Table 3 Measurements taken 1-2 days without rain

Sample Computation:

$$V = \frac{D}{T} = \frac{3m}{13.47s} = 0.22m/s$$

$$V_{ave} = \frac{0.22+0.16+0.13+0.25+0.13+0.23}{6} = 0.19m/s$$

Section	1	2	3
Width (m)	4	3.47	3.83
Depth 1 (m)	0.38	0.51	0.21
Distance 1(m)	0.5	0.5	0.5
Depth 2 (m)	0.45	0.6	0.3
Distance 2 (m)	2	1.74	1.91
Depth 3 (m)	0.56	0.79	0.45
Distance 3(m)	3.5	2.97	3.33

Table 4 River profile measurements

ANNEX A FLOW MEASUREMENTS

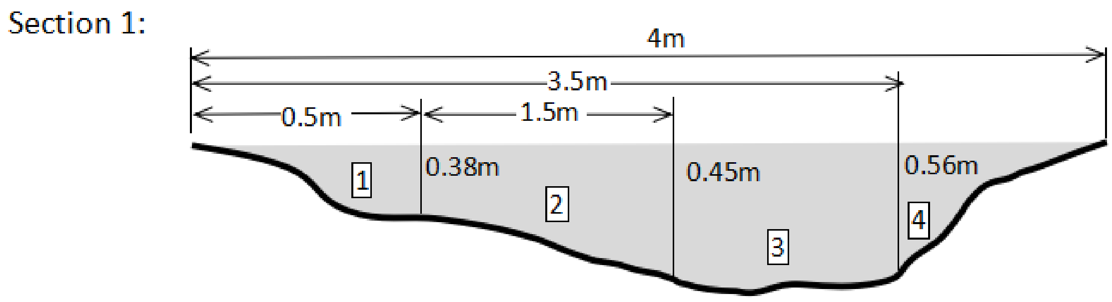

Figure 3 Situational sketch section 1

$$A_1 = \frac{1}{2}(0.38)(0.5) = 0.095m^2$$

$$A_2 = \frac{1}{2}(0.38 + 0.45)(1.5) = 0.6225m^2$$

$$A_3 = \frac{1}{2}(0.45 + 0.56)(1.5) = 0.7575m^2$$

$$A_4 = \frac{1}{2}(0.56)(0.5) = 0.14m^2$$

$$A_{total} = 0.095 + 0.6225 + 0.7575 + 0.14 = 1.615m^2$$

ANNEX A FLOW MEASUREMENTS

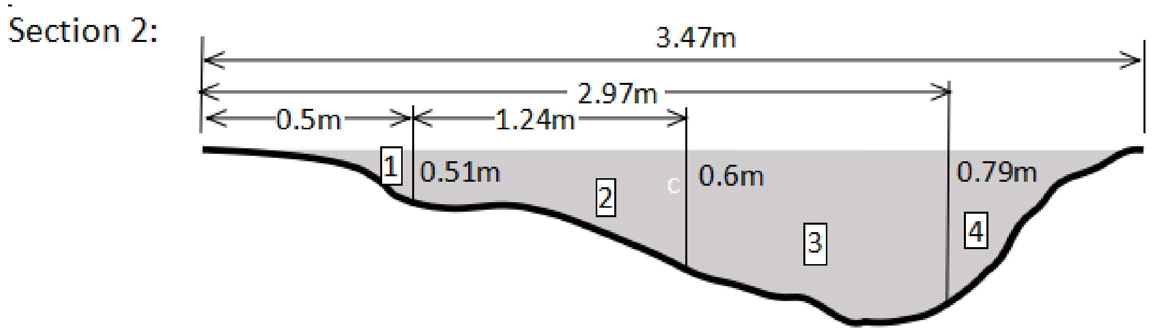

Figure 4 Situational sketch section 2

$$A_1 = \frac{1}{2}(0.51)(0.5) = 0.1275m^2$$

$$A_2 = \frac{1}{2}(0.51 + 0.6)(1.24) = 0.6882m^2$$

$$A_3 = \frac{1}{2}(0.6 + 0.79)(1.23) = 0.85485m^2$$

$$A_4 = \frac{1}{2}(0.79)(0.5) = 0.1975m^2$$

$$A_{total} = 0.1275 + 0.6882 + 0.85485 + 0.1975 = 1.86805\,m^2$$

Section 3:

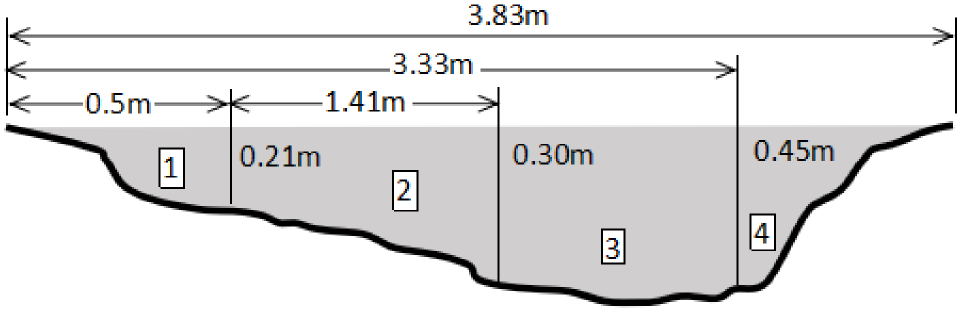

Figure 5 Situational sketch section 3

$$A_1 = \frac{1}{2}(0.5)(0.21) = 0.0525m^2$$

$$A_2 = \frac{1}{2}(0.21 + 0.30)(1.41) = 0.35955m^2$$

$$A_3 = \frac{1}{2}(0.3 + 0.45)(1.42) = 0.5325m^2$$

$$A_4 = \frac{1}{2}(0.5)(0.45) = 0.1125m^2$$

$$A_{total} = 0.0525 + 0.35955 + 0.5325 + 0.1125 = 1.05705\,m^2$$

$$A_{ave} = \frac{1.86805 + 1.615 + 1.05705}{3} = 1.513m^2$$

$$Q = A_{ave}(V_{ave}) = 1.513m^2(0.19m/s)$$

$$Q = 0.29m^3/s$$

ANNEX A FLOW MEASUREMENTS

To determine the discharge of the river, velocity and the cross-section of an area should first be calculated.

Distance (m)	Time (s)	Velocity (m/s)
3	9.05	0.33
3	11.51	0.26
3	12.05	0.25
3	15.17	0.2
3	12.02	0.25
3	12.29	0.24
Average	12.02	0.25

Table 5 Measurements taken after light rainfall

Sample Computations:

$$V = \frac{D}{T} = \frac{3m}{9.05s} = 0.33m/s$$

$$V_{ave} = \frac{0.33 + 0.26 + 0.25 + 0.2 + 0.25 + 0.24}{6} = 0.25m/s$$

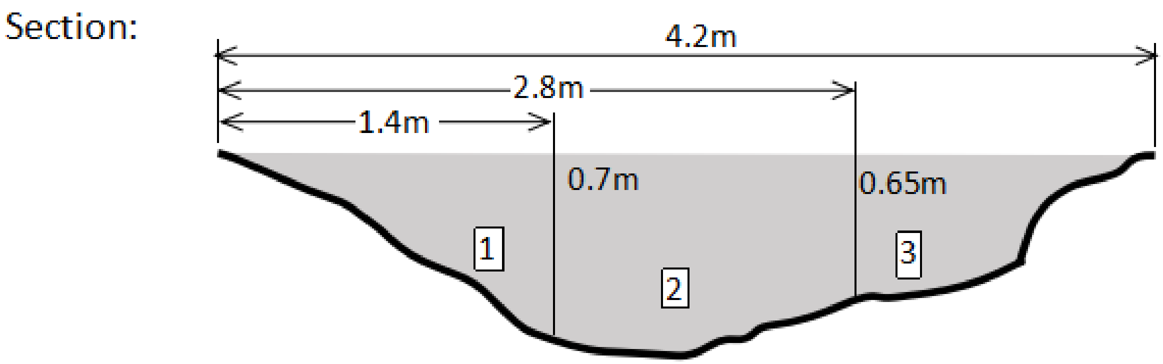

Figure 6 Situational sketch section after raining

$$A_1 = \frac{1}{2}(1.4)(0.7) = 0.49m^2$$

$$A_2 = \frac{1}{2}(0.7 + 0.65)(1.4) = 0.945m^2$$

$$A_3 = \frac{1}{2}(1.4)(0.65) = 0.455m^2$$

$$A_{total} = 0.49 + 0.945 + 0.455 = 1.89m^2$$

$$Q = A_{total}(V_{ave}) = 1.89m^2(0.25m/s)$$
$$Q = 0.47m^3/s$$

ANNEX A FLOW MEASUREMENTS

Shown below is the graph of the pressure versus temperature taken from the mini-diver submerged in the river channel for more than 2 minutes.

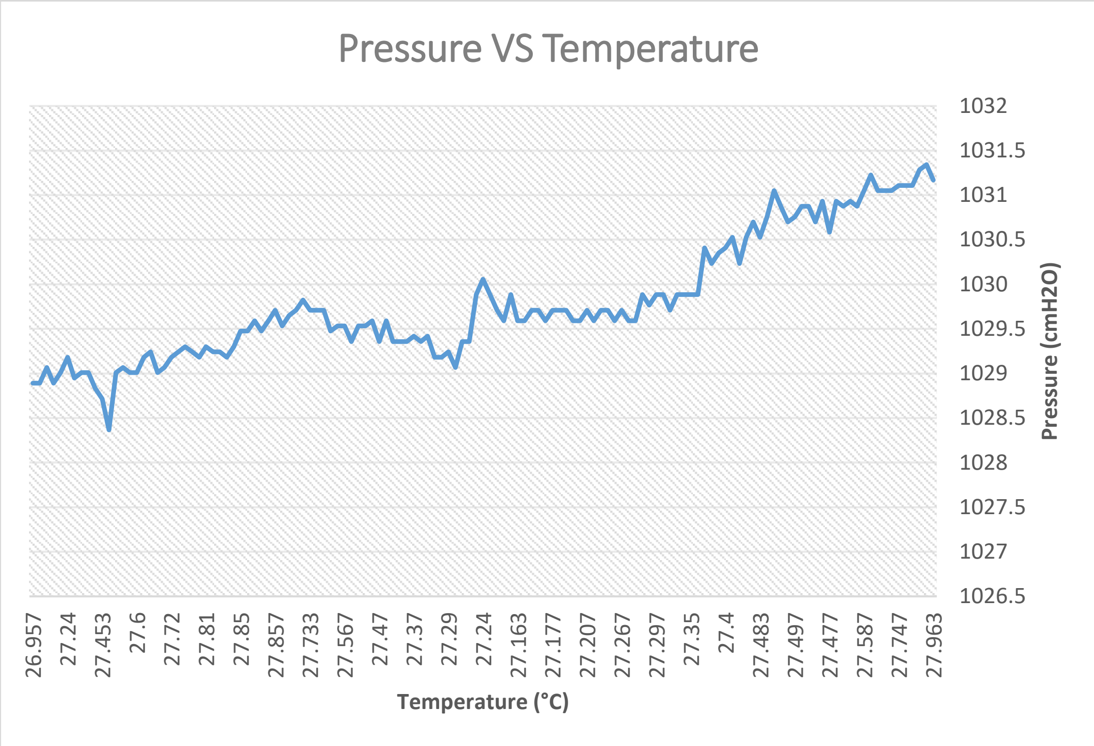

Figure 7 Pressure vs temperature diagram

ANNEX B MAXIMUM FLOOD HEIGHTS

Image 3 First high water measurement Butuanon river at the Canduman-Cabancalan bridge

Image 4 Second high water measurement Butuanon river at the Canduman-Cabancalan bridge

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 5 Top left River clean up opposite pacific mall, bottom left Fisherman catching plastic waste, top right children at illegal mangrove settlement, bottom right riverside dwellings

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 6 Left child getting ready for a bath Cabancalan slums, right Small fish swimming in the Butuanon (highly poluted river

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 7 Top left Toat at rivers edge Butuanon river, bottom left severly poluted ground water Butuanon river, top right severely poluted water Butuanon river with white discharge , bottom right Illegal dumpsite Cabancalan

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 8 Left sewer discharge Canduman-Cabancalan bridge, top right puppy's at illegal squaters dwelling Cabancalan ,bottom right esidential area Cabancalan along the Butuanon river

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 9 Left garbage collector Cabancalan, top right Illegal small scale ssand delving on the banks of the Butuanon river, bottom right severly poluted groundwater and plastic waste at the Umapad dumpsite

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 10 Left cock fighting rooster Cabancalan barangay, left Livestock near Canduman-Cabancalan bridge

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 11 Top left family of goats resting in the shade Canduman-Cabancalan bridge, bottom left Interviewing local man in Cabancalan, top right Umapad dumpsite, bottom right interviewing garbage pickers on the banks of the Butuanon river

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 12 Left measuring electrical conductivity Butuanon river, top right Upstream group 5 & 6 assesing the state of the Butuanon river, bottom left Measuring Butuanon river profile near Canduman-Cabancalan bridge

ANNEX C PICTURE GALLERY OF BUTUANON RIVER

Image 13 Upstream group 5 & 6 Canduman-Cabancalan bridge

ANNEX D RIVER WIDTH USE SMART MEASURE APP

There river in the upstream area, under the Canduman-Cabancalan bridge has varying widths with many protruding rocks at the middle and sides. This leads to a large variation in the velocity of the river, so a location with little obstacles and almost the same width was chosen.

The width can be measured with the use of the Smart Measure app, or it can be done manually. Doing both measurements, the values of the determined width are close to each other and the data gathered manually was retained. The measurement locations are represented by section 1-3 (Table 6) a visual representation of the measurement location is depicted in Image 14.

Section	Width (m)
1	4
2	3.47
3	3.83

Table 6 Width measurements

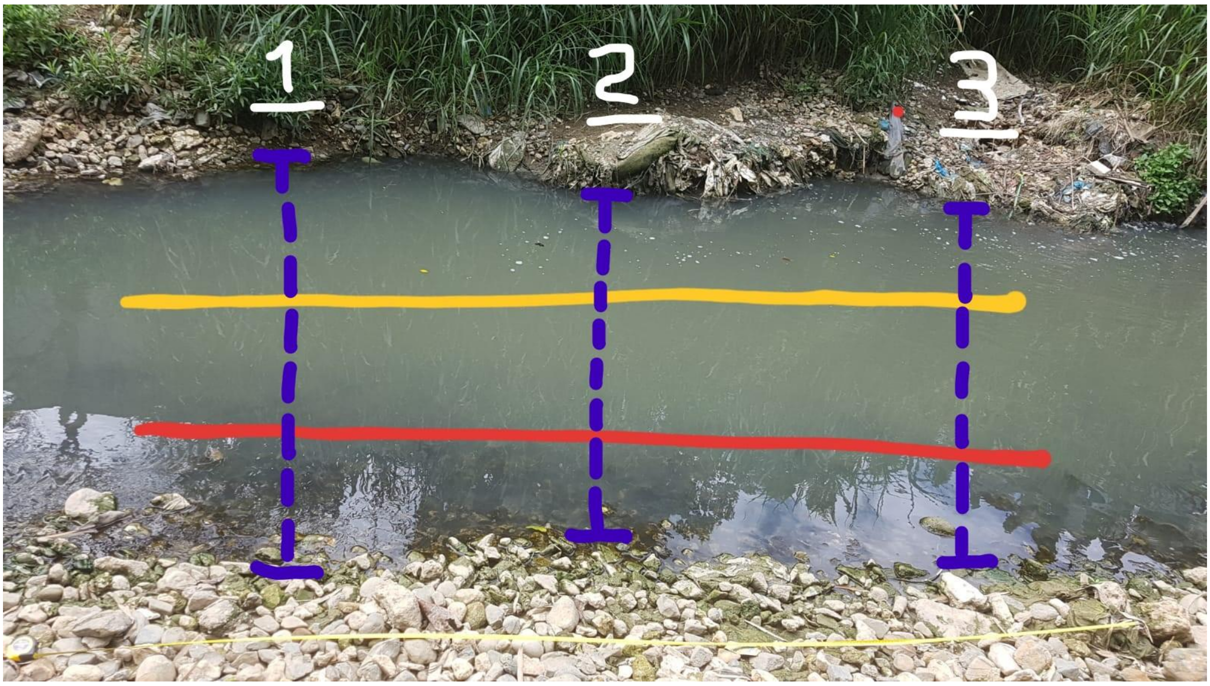

Image 14 Measurement location upstream group 6

ANNEX E URBAN WATER QUALITY

Table 7 shows the results taken from the Butuan river on the 14th of November 2018. Unfortunately using the Akvo Caddisfly app for testing the water quality of the river proved unsuccessful. Therefor the information needed was acquired using the Hach test strips. The dissolved oxygen (DO) meter and data logger provided the remaining information.

Section	Time h:mm A	K (µS/cm)	Temperature (°C)
1	1:35 PM	1188	29.5
		1203	
		1204	
2	1:37 PM	1221	29.1
		1224	
		1228	
		1238	
3	1:39 PM	1209	29.1
		1211	

Table 7 Electrical conductivity and temperature measurements per section over a 5-minute period

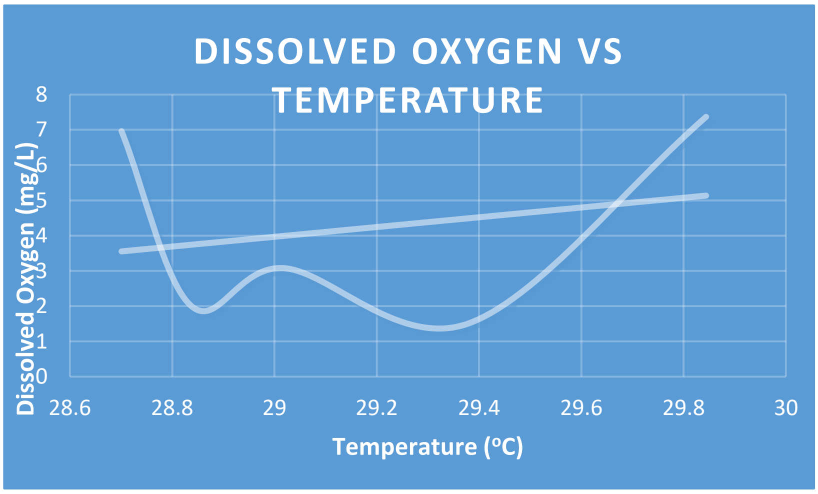

Figure 8 Dissolved Oxygen VS Temperature

DO (mg/L)	T (°C)
7.368	29.844
1.508	29.379
3.079	29.018
1.997	28.838
6.964	28.701

Table 8 Dissolved oxygen and temperature

The values measured for the electrical conductivity is within range for the typical values of a river system (Class D water). Electrical conductivity is directly linked to salinity. Conductivity, "specific conductance", is one of the most useful and commonly measured water quality parameters. In addition to being the basis of most salinity and total dissolved solids calculations, conductivity is an early indicator of change in a water system. Significant change, whether it is due to natural flooding, evaporation or man-made pollution can be very detrimental to water quality (Fondriest Environmental, Inc., 2014).

Conductivity and salinity have a strong correlation. As conductivity is easier to measure, it is used in algorithms estimating salinity and total dissolved solids (TDS), both of which affect water quality and aquatic life (Fondriest Environmental, Inc., 2014).

The electrical conductivity exceeds the limit that can sustain diverse aquatic life which is 500 µS/cm. Based on these findings it can be expected that little to no aquatic fauna can be found along this part of the Butuanon river. Table 9 show that there is a correlation between temperature, depth and oxygen levels. This is further illustrated by Figure 9. The more aerated water at the surface has a higher oxygen level as can be expected. The underlying water column has no direct contact with the oxygen rich air and therefore the findings of DO levels measured in section 1 aren't representative of the water quality. According to Gay-Lussac's Law (Helmenstine, 2017) temperature and pressure are directly proportional to each other. This means that as the pressure increases, the temperature increases. This explains why initially the water temperature rises thus decreasing the oxygen levels.

Section	Time h:mm AM/PM	Electrical conductivity (mS/cm)	Temperature (°C)	DO (mg/L)
1	1:35 PM	1.188	29.500	
		1.203	29.844	7.3680
		1.204		
2	1:37 PM	1.221	29.100	
		1.224	29.379	1.5080
		1.228	29.018	3.0790
		1.238	29.100	
3	1:39 PM	1.209	28.838	1.9970

Table 9 Electrical conductivity, temperature and dissolved measurements per section over a 5-minute period

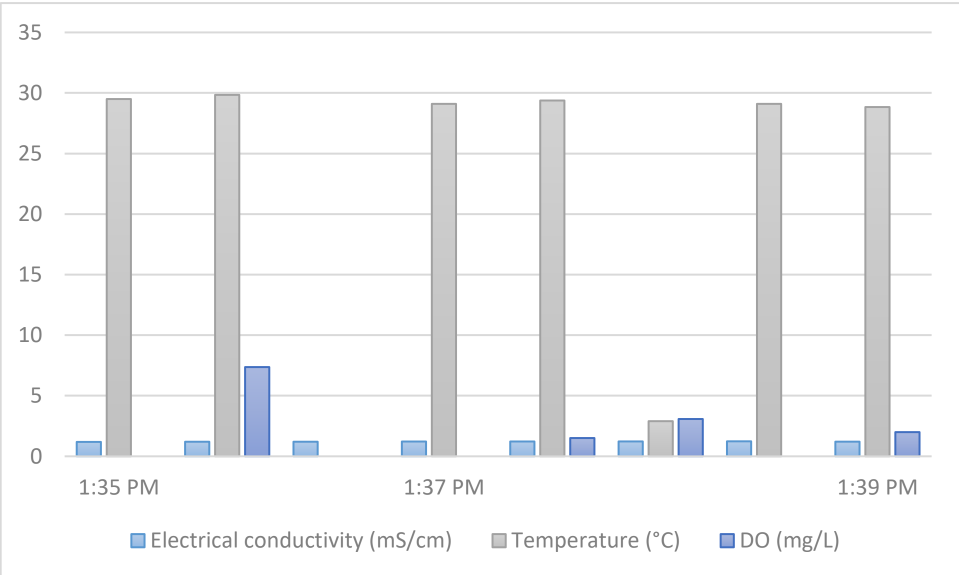

Figure 9 Electrical conductivity temperature and dissolved oxygen measurements per section over a 5-minute period

Using the Hach test strips iron, phosphorus, pH, nitrate and nitrite can be determined. The strips indicate that there are low concentrations of iron found in the water (Table 10). The pH level of the river is 8-9 which is comparable to ocean water. The optimum pH for river water is around 7.4. A pH level of 8.0 can sustain most river life apart from mussels, clam and snails. Phosphate levels reached the highest with a range of 5-15. This range is higher than that of the Pasig river.

ANNEX E URBAN WATER QUALITY

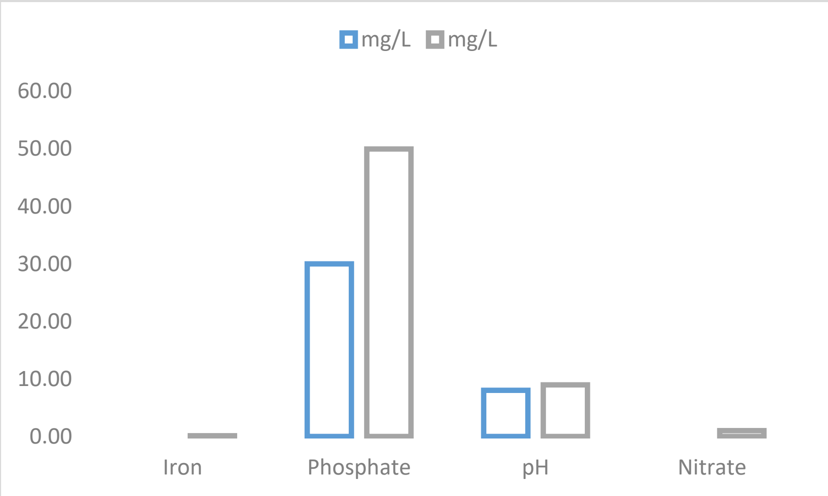

Figure 10 Water quality measurements

Strips	mg/L
Iron	0-0.15
Phosphate	30-50
pH	8-9
Nitrate	0-1

Table 10 Water quality measurements

As for the dissolved oxygen values, it can be affected by three factors:
salinity, pressure and temperature. Temperature mainly affects the amount of oxygen dissolved since it interferes with the reaction of particles in the water. The three lowest points on the graph are the points in which the data logger was submerged in the river.

Excessive amounts of nitrate or nitrite in water can cause infant death, adult illness, and produce spontaneous abortion in cows. When water contains high nitrate levels, nitrites often are present in low concentration (Hach, 2018). Due to the severely polluted state of the Butuanon river, one could expect to find high concentrations of nitrate. However, the concentrations measured do not reflect that hypothesis. Considering that the test location was adjacent to the sewer discharge point of a poultry farm, many other production facilities and residential areas the conclusion must be that the gathered date is faulty. As to where the fault lies, possibly the strips were damaged during transit or the measurements were done incorrectly. Therefore, no conclusion of any merit can be made from the data.

Due to a lack of data no real conclusions as to the quality of the river water can be made. Therefore, a qualitative research had been done. The information presented by CNU Journal of Higher Education named

<u>Additional information concerning the physicochemical parameters Butuanon river:</u>
Water samples (n=3 per barangay) were analyzed for physicochemical and microbiological indicators. Results show that majority of households (75%) dump plastic waste and some (6.7%) dispose human and animal waste into the river. These practices resulted to the low dissolved oxygen (0-0.4 mg/L DO) which suggest that the river cannot sustainably support diverse aquatic life (CNU Journal of Higher Education, 2012).

pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	Turbidity (NTU
5-9	> 3	≤ 15	≤ 250	≤ 50

*Table 11 Standard values (Class D water) reference **(CNU Journal of Higher Education, 2012)** e*

ANNEX E URBAN WATER QUALITY

Barangay	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	Turbidity (NTU)
Alang - alang	6.61	0.4	88	203	4.7
Cabancalan	**6.88**	**0**	**22**	**43**	**3.4**
Canduman	**6.98**	**0**	**8**	**62**	**1.6**
Casuntingan	7.51	0	44	87	5.3
Ibabao	5.89	0	369	597	13
Manguikay	7.39	0	13	57	2.3
Paknaan	6.67	0	129	256	12
Tabok	4.51	0	249	505	7
Tingub	6.78	0	26	49	3-4
Umapad	6.67	0	379	422	20

Table 12 Values physicochemical parameters Butuanon river ***(CNU Journal of Higher Education, 2012)***

ANNEX **F** RIVERINE PLASTIC WASTE POLLUTION

There are supposedly three methods of OSPAR monitoring to be tested and validated - namely: standard, randomized, and high-water level mark - but due to the characteristic of the riverbank having wild vegetation at its steep slopes and having inaccessible riverbanks, only the randomized OSPAR riverbank monitoring was carried out.

The purpose of this method is to determine the amount of persistent wastes that are discharged into the oceans daily, weekly, monthly, and so on. The main concern for this is the ingestion of these wastes to marine animals which is an example of how the food chain is disrupted.

Cartons e.g. tetra packs (other)	62	1	
Cigarette butts	64	1	
Cups	65	2	
POTTERY/CERAMICS			2
Construction material e.g. tiles	94	3	
METAL			4
Food cans	82	3	
Paint tins	86	1	
OTHER ITEMS			11
Slippers	53	1	
Leg of a chair	74	1	
Broken glasses	93	3	
Chinaware	96	2	
Picture frame parts	74	1	
Diaper	102	1	
Battery	89	1	
Wooden broom	75	1	
	TOTAL ITEMS:		196

Table 13 Riverine plastic paste pollution survey results

ANNEX G ECOLOGY OF THE RIVER

AVERAGE SCORE	6.8
GROUPS	**SENSITIVITY SCORE**
Flat worms	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
True flies	2
Snails	4
TOTAL SCORE	34
NUMBER OF GROUPS	5

Table 14 Ecology of the Butuanon river upstream group 6 location

Ecological category (Condition)	River Category	
	Sandy Type	**Rocky Type**
Unmodified (NATURAL Condition)	> 6.9	> 7.9
Largely natural/few modifications (GOOD Condition)	5.8 to 6.9	6.8 to 7.9
Moderately modified (FAIR Condition)	4.9 to 5.8	6.1 to 6.8
Largely modified (POOR Condition)	4.3 to 4.9	5.1 to 6.1
Seriously/critically modified (VERY POOR Condition)	< 4.3	< 5.1

Table 15 Ecology score mini-SASS upstream group 6 location

ANNEX **H** RIVER STREAM VELOCITY

TUESDAY, NOVEMBER 13, 2018

Distance (m)	Time (s)	Velocity (m/s)
3	1.47	0.22
3	19.01	0.16
3	22.88	0.13
3	12.03	0.25
3	23.12	0.13
3	12.88	0.23
	Velocity(ave) =	0.19

Table 16 Upstream group6 river stream velocity measurements Nov. 13, 2018

WEDNESDAY, NOVEMBER 14, 2018

The following are the measurements taken after the rain in the morning:

Distance (m)	Time (s)	Velocity (m/s)
3	9.05	0.33
3	11.51	0.26
3	12.05	0.25
3	15.17	0.2
3	12.02	0.25
3	12.29	0.24
	Velocity(ave) =	0.25

Table 17 Upstream group6 river stream velocity measurements Nov. 14,

ANNEX I TURBIDITY WITH HYDRO COLOR & SECCHI DISK

Secchi Disk	Units (cm)
Disappearing depth	45
Reappearing depth	40

Table 18 Turbidity measured with Secchi disk

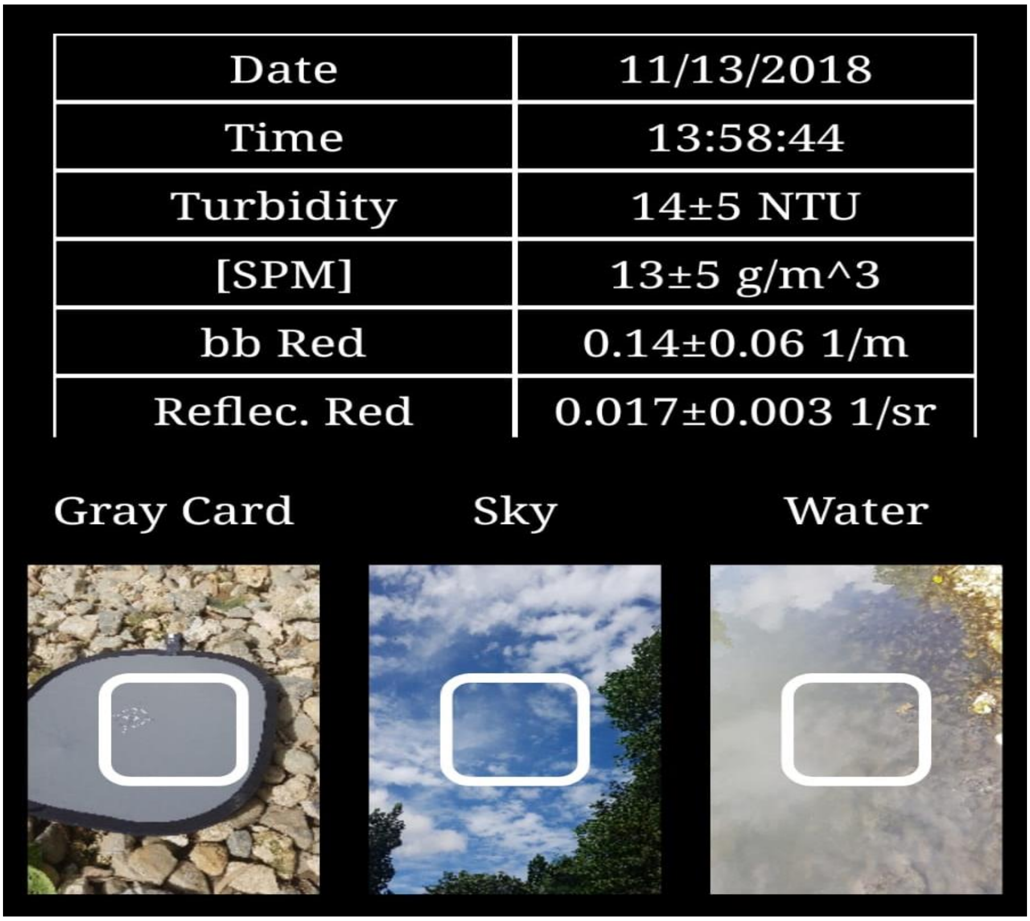

Image 15 Screenshot taken from the Hydro color application

ANNEX J PM-TOOL

nr.	Project activities	Peita	Rachel	Leonard	James	Totalen	Starts on day	Ends on day
		Hour estimate project group members					Planning activities	
1	**Field work**							
2	Assignment 3. Storytelling video				3	3	1	5
3	Assignment 4. Flow measurements	2	5	5	2	14	2	4
4	Assignment 5. Maximum Flood heights	2	3	3		8	2	4
5	Assignment 6. Picture gallery of Butuanon River	1	1	1	3	6	2	4
6	Assignment 7. River width use Smart measure app				1	1	2	3
7	Assignment 8. Urban Water Quality		2	2		4	2	2
8	Assignment 9. Riverine Plastic Waste Pollution		3	3		6	2	3
9	Assignment 10. Web-based mapping, Climatescan				1	1	2	4
10	Assignment 11. Ecology of the river	2	2		1	5	2	2
11	Assignment 12. River stream velocity	1	4	4	1	10	2	3
12	Assignment 13. Turbidity with Secchi Disk			2	1	3	2	4
13	Assignment 14. Turbidity with Hydrocolor				1	1	2	3
14	Assignment 15. Quick Scan Android devices				1	1	4	4
15	**Research & development**							
16	Plan of Action				3	3	2	2
17	PM-tool				2	2	2	2
18	Initial Layout				2	2	2	2
19	Assignment 1. Group paper	3	3	3	3	12	4	5
20	Assignment 2. Poster & Pitch		4	4		8	6	7
21	Assignment 3. Storytelling video				4	4	4	7
22	Assignment 4. Flow measurements		3			3	2	3
23	Assignment 5. Maximum Flood heights			3		3	2	3
24	Assignment 6. Picture gallery of Butuanon River				3	3	2	4
25	Assignment 7. River width use Smart measure app				1	1	3	3
26	Assignment 8. Urban Water Quality		2	2		4	2	4
27	Assignment 9. Riverine Plastic Waste Pollution		2	2	2	6	2	3
28	Assignment 10. Web-based mapping, Climatescan				2	2	3	4
29	Assignment 11. Ecology of the river	3				3	2	3
30	Assignment 12. River stream velocity			3		3	2	3
31	Assignment 13. Turbidity with Secchi Disk		2	2		4	2	4
32	Assignment 14. Turbidity with Hydrocolor		2	2		4	3	4
33	Assignment 15. Quick Scan Android devices				2	2	4	4
34	Final editing				2	2	5	5
	Totalen	**14**	**38**	**41**	**41**	**134**		

Table 19 Estimated hours of the project team members

ANNEX J PM-TOOL

nr.	Project activities	Hour registration project group members				% Ready		Starting day	Previous day
		Peita	Rachel	Leonard	James				
1	**Field work**								
2	Assignment 3. Storytelling video					100		1	8
3	Assignment 4. Flow measurements					100		2	8
4	Assignment 5. Maximum Flood heights					100		2	8
5	Assignment 6. Picture gallery of Butuanon River					100		2	8
6	Assignment 7. River width use Smart measure app					100		2	8
7	Assignment 8. Urban Water Quality					100		2	8
8	Assignment 9. Riverine Plastic Waste Pollution					100		2	8
9	Assignment 10. Web-based mapping, Climatescan					100		2	8
10	Assignment 11. Ecology of the river					100		2	8
11	Assignment 12. River stream velocity					100		2	8
12	Assignment 13. Turbidity with Secchi Disk					100		2	8
13	Assignment 14. Turbidity with Hydrocolor					100		2	8
14	Assignment 15. Quick Scan Android devices					100		4	8
15	**Research & development**								
16	Plan of Action				4	100		2	8
17	PM-tool				3	100		2	8
18	Initial Layout				2	100		2	8
19	Assignment 1. Group paper					100		4	8
20	Assignment 2. Poster & Pitch					100		6	8
21	Assignment 3. Storytelling video					100		4	8
22	Assignment 4. Flow measurements					100		2	8
23	Assignment 5. Maximum Flood heights					100		2	8
24	Assignment 6. Picture gallery of Butuanon River				3	100		2	8
25	Assignment 7. River width use Smart measure app					100		3	8
26	Assignment 8. Urban Water Quality					100		2	8
27	Assignment 9. Riverine Plastic Waste Pollution					100		2	8
28	Assignment 10. Web-based mapping, Climatescan					100		3	8
29	Assignment 11. Ecology of the river					100		2	8
30	Assignment 12. River stream velocity					100		2	8
31	Assignment 13. Turbidity with Secchi Disk					100		2	8
32	Assignment 14. Turbidity with Hydrocolor					100		3	8
33	Assignment 15. Quick Scan Android devices					100		4	8
34	Final editing					100		5	8
	Totalen	**0**	**0**	**0**	**12**				

Table 20 Hour registration project group members

ANNEX J PM-TOOL

nr.	Project activities	Projected	Made	Still to make	Deficit	Activiteiten Status		
1	Field work							
2	Assignment 3. Storytelling video	3	0	3	0		done	overdue
3	Assignment 4. Flow measurements	14	0	14	0		done	overdue
4	Assignment 5. Maximum Flood heights	8	0	8	0		done	overdue
5	Assignment 6. Picture gallery of Butuanon River	6	0	6	0		done	overdue
6	Assignment 7. River width use Smart measure app	1	0	1	0		done	overdue
7	Assignment 8. Urban Water Quality	4	0	4	0		done	overdue
8	Assignment 9. Riverine Plastic Waste Pollution	6	0	6	0		done	overdue
9	Assignment 10. Web-based mapping, Climatescan	1	0	1	0		done	overdue
10	Assignment 11. Ecology of the river	5	0	5	0		done	overdue
11	Assignment 12. River stream velocity	10	0	10	0		done	overdue
12	Assignment 13. Turbidity with Secchi Disk	3	0	3	0		done	overdue
13	Assignment 14. Turbidity with Hydrocolor	1	0	1	0		done	overdue
14	Assignment 15. Quick Scan Android devices	1	0	1	0		done	overdue
15	Research & development							
16	Plan of Action	3	4	0	1		done	overdue
17	PM-tool	2	3	0	1		done	overdue
18	Initial Layout	2	2	0	0		done	overdue
19	Assignment 1. Group paper	12	0	12	0		done	overdue
20	Assignment 2. Poster & Pitch	8	0	8	0		done	overdue
21	Assignment 3. Storytelling video	4	0	4	0		done	overdue
22	Assignment 4. Flow measurements	3	0	3	0		done	overdue
23	Assignment 4. Flow measurements	3	0	3	0		done	overdue
24	Assignment 5. Maximum Flood heights	3	3	0	0		done	overdue
25	Assignment 6. Picture gallery of Butuanon River	1	0	1	0		done	overdue
26	Assignment 7. River width use Smart measure app	4	0	4	0		done	overdue
27	Assignment 8. Urban Water Quality	6	0	6	0		done	overdue
28	Assignment 9. Riverine Plastic Waste Pollution	2	0	2	0		done	overdue
29	Assignment 10. Web-based mapping, Climatescan	3	0	3	0		done	overdue
30	Assignment 11. Ecology of the river	3	0	3	0		done	overdue
31	Assignment 12. River stream velocity	4	0	4	0		done	overdue
32	Assignment 13. Turbidity with Secchi Disk	4	0	4	0		done	overdue
33	Assignment 14. Turbidity with Hydrocolor	2	0	2	0		done	overdue
34	Assignment 15. Quick Scan Android devices	2	0	2	0		done	overdue
	Totalen	71	12	61	2			

Table 21 Progres monitoring project group members