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Roong Aroon Wastewater Treatment Project

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We are the water treatment project team from Roong Aroon High School in Bangkok, Thailand. Our team consists of four grade 12 science major students, and every one of us has been studying and working on developing our school's water treatment system. This article explains how the "Problem Based Learning" (PBL) process proceeds throughout our project.

During our junior year, we studied about the variety of environmental problems through an assigned project. We realized that *wastewater* is one of the problems, which strongly relates to us, since we use water for cleaning ourselves, dishes, and even in the use of manufactured goods. After water is used, it becomes contaminated and is disposed into natural water sources. This contaminated water ruins the aquatic eco-system and causes further damages. For these reasons, we chose to place our interest on the wastewater issue.

After we had identified what we were interested in, we traced back the pathway of the water. To begin our research, we went to a forest in Chiang Mai province in the north of Thailand, where the pathway starts. We examined the quality of water by observing aquatic organisms, because each type has a different tolerance in different water qualities. For example, mayflies, which were found, can survive only in the cleanest natural water possible. This observation told us that the water was really clean. Next, we searched for more information to assure how water gets contaminated and becomes wastewater. We knew that wastewater is produced from human usage. Similarly, it is acknowledged that our school, a big community, produces a massive quantity of wastewater. In fact, our school had realized this problem and began a water treatment project 8 years ago.

Our curriculum is based on Problem Based Learning, which includes 3 main processes: identifying the problem, identifying and researching the knowledge required, and applying the knowledge to solve the problem.

Identifying the problem

In this process, we examined the water quality around the school grounds by measuring the Chemical Oxygen Demand (COD) in several places. We measured from the steam next to the school to the water treatment systems in the school (Our school had an awareness of this problem too). As a result, we noticed that the water treatment system in one of our school's buildings (Patharapa) was inefficient (treated water's COD $>$ 120 mg/L)[1]. Therefore, we decided that our project would be focusing on this system.

[1] For more information, see *Table 1. COD Table for the Patharapa wastewater treatment system*

Figure 1. Patharapa's water treatment system

Identifying and researching knowledge required

In order to solve the problem, information shown in Figure 2 was required.

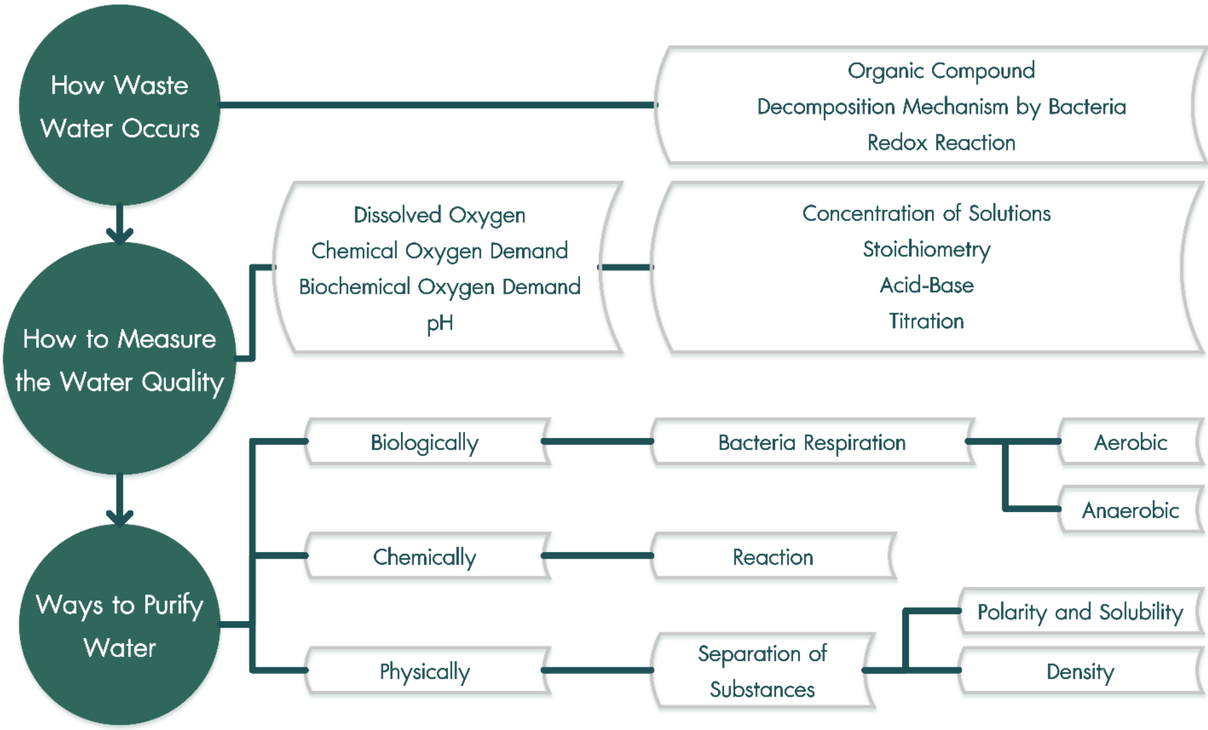

Figure 2. Required information diagram

As can be seen on the right side of Figure 2, basic knowledge from the school's classes is an important foundation in order to understanding the further solution to our problem. For example, we had learned about Redox Reactions, Concentration of Solutions, Stoichiometry, Acid-Base, and Titration in chemistry class. These topics enhanced our understanding when we have to prepare several solutions in the measuring the water quality process in the laboratory.

An example of the information we needed to understand in order to solve the problem is how to measure Chemical Oxygen Demand (COD), which is a process for measuring the quantity of organic matter in the water.

After calculating the amount of potassium dichromate needed to oxidize the organic material in the water and then adding it to the sample, we titrated with iron and observed any color change. A change from green to red-brown indicated to us that there were organic compounds in the water supply.[2]

Another example of the information our literary research showed we needed to understand in order to solve the problem was to understand the concept of using biological ways to treat the water by knowing the nature of bacteria that digests the organic matter naturally. This means leaving the wastewater alone, and letting every organic compound in the water to be digested at some point. However, this natural process takes a lot of time. This is where a water treatment system plays a role by helping the bacteria to digest faster.

The next step was to understand the former water treatment system in our school, which was begun in 2006.

We started by observing the nature of the water first. We then found out that wastewater, which runs into this system, is contaminated by the use in everyday life, such as dish washing, cooking, and even washing hands.

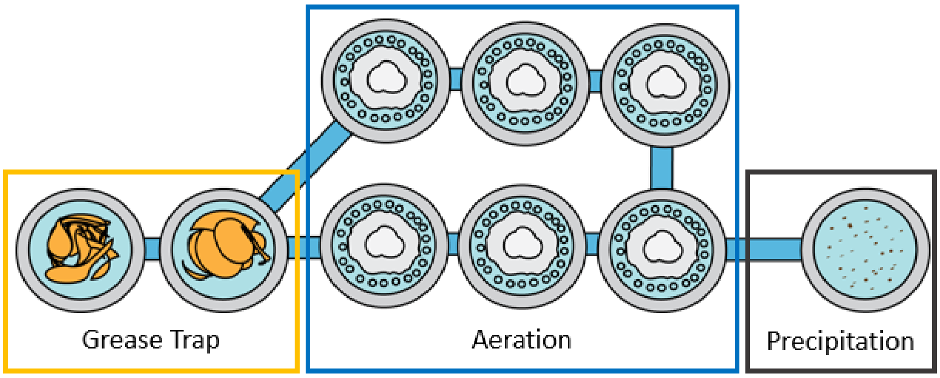

Figure 3. Diagram of previous water treatment system at Patharapa building

Figure 3 illustrates how the old water treatment system worked. As can be seen, the system is separated into 3 sections:

1. Grease trap – In this part, wastewater is left for a day until grease floats to surface of the water, because grease molecules are non-polar, yet water is a polar molecule, so grease is never soluble in water. After that, we scoop the grease out of the system. We have to remove the grease because its molecule is bigger than other organic compounds in the water.

2. Aeration – In this part, oxygen is added to the water in the system. We need to add oxygen to the water because there are two types of bacteria. The first type, aerobic bacteria, uses oxygen to digest organic compounds. The second type, anaerobic bacteria, does not require oxygen.

However, aerobic bacteria is far more efficient in digestion, because anaerobic bacteria's cellular respiration only goes through "glycolysis", while aerobic bacteria, using oxygen, continues through the "Krebs cycle" and "Electron Transport Chain" in cellular respiration. Because of the incomplete process, anaerobic bacteria produce a small amount of CO_2 with still a lot of organic material and distinct-odor gas left. In contrast, aerobic bacteria are able to digest every organic compound, producing CO_2 and water. This is why we need to add oxygen into the water: to provide enough oxygen for aerobic bacteria to do its job.

[2] Summarized from: Top Publishing (2006) **Wastewater Treatment System :** Selection, Design, Operation and Problem Solving.

3. Precipitation – This section is important because after the bacteria digest the organic compounds, some of the compounds are transformed into the bacteria's mass. If we do nothing more, the water will eventually become full of bacteria. Thus, in this precipitation part, we left the water to stay still, allowing all the more massive and dense bacteria to sink to the bottom of the tank, leaving the cleaned water on top.

Application to solve the problem

After identifying the problem and gathering information, we concluded that we should work in 2 parts. The first part was to create our own water treatment system to treat the wastewater that was unavoidably released. The second part was to reduce the quantity of used water.

There were 9 sub-processes in the first part.

1. Measured the treated water from the old system by checking the COD. The purpose of checking the COD was to understand how bad the wastewater was. From the results in Table 1 below, we could clearly see that the system had a problem. (The standard for COD value must not exceed 120 mg/L[3])

Table 1. COD Table for the Patharapa wastewater treatment system

Date	COD (mg/L)
March 7, 2014	293
March 19, 2014	361
March 20, 2014	314
March 21, 2014	312
Average	320

2. After we knew that the system had a problem, we decided to do another test. This experiment's purpose was to identify whether the system provided adequate oxygen to bacteria or not. The method we used was to measure the amount of Dissolved Oxygen (DO) in each aeration tank. The result of the experiment indicated that there was inadequate oxygen even in the last tank of the aeration part, letting us know that there was a problem with the aeration system.

3. From the previous experiment we knew that the aeration system had a problem, however, we did not know if the problem was from the aeration system itself or from the inadequate sizes of each of the system's tanks compared with the amount of wastewater per day. This led us to measure the quantity of wastewater per day, by draining the tank at the end of the day and measuring the incoming water. The result of the measurement illustrated that Patharapa building generated approximately 2.45 cubic meters of wastewater each day. We realized that the grease trap section and the precipitate section were inadequate in size to trap grease or precipitate the bacteria effectively.

4. According to the outcome of the previous measurement, we knew that we needed to design a new system for the grease trap and precipitation sections in order to cope with the excess quantity of income wastewater. While designing the new system, we always considered these factors: Capacity, Limited Area, Height (for odor and appearance sake),

[3] As specified by the Pollution Control Department of Thailand

and for maintenance. The final plan is shown in Figure 5. The area of each is noted in the space at the lower part of the diagram.

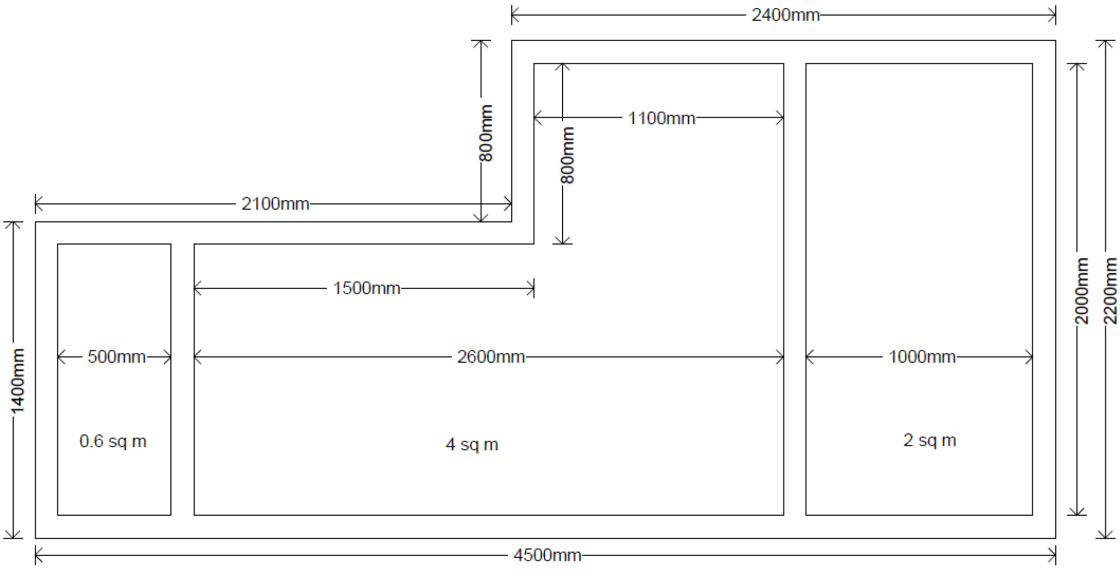

Figure 4. Our Construction Plan for The New Grease Trap Section (top view)[4]

5. After the design process, we proposed the plan to teachers and construction crews in order to improve the plan and get the budget[5] approved by the Budget Department of our school. This process took approximately 3 months.

6. The construction team commenced the construction process with help from us.

7. After the construction was completed, we noticed that the treated water did not look clear, and there were still lots of noticeable particles. Moreover, we noticed that bubbles from detergent, which is used for washing dishes, still existed unequally in the oxygen section, which led us to the hypothesis that the water does not pass each side of the aeration section equally.

So, we designed another experiment to measure the quantity of water going into each side per day. We drained all the water out from the aeration section, then we waited until the end of the day and measured how much water went into the section. The result is shown below. You can see that the water went into the orange side more than the red side by nearly one and a half times.

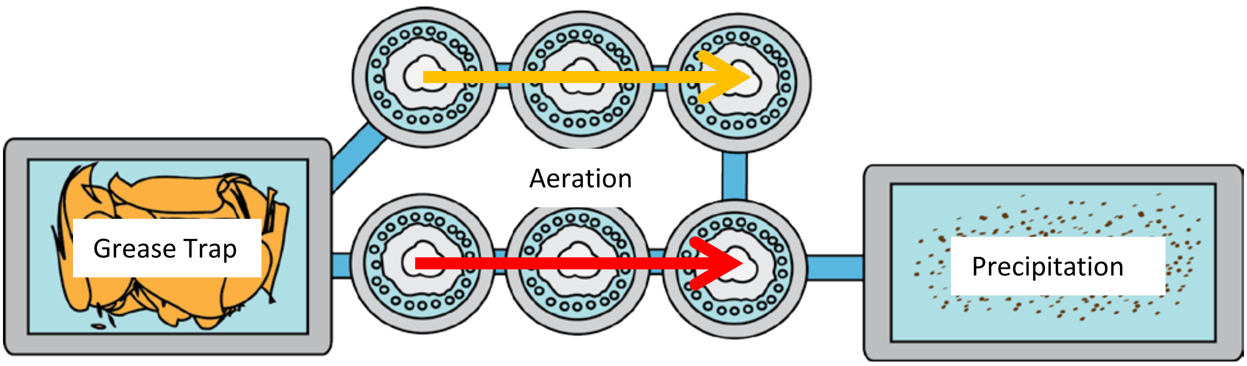

Figure 5. Water flow through old system

[4] Construction plans of grease trap and precipitation section are provided in the appendix.
[5] Table of budget is included in appendix.

Table 2. Indication that the water does not flow equally

	RED SIDE	ORANGE SIDE
Average (m^3)	1.029	1.434

8. Consequently, we rearranged the pipes, so that the water went into each side equally.

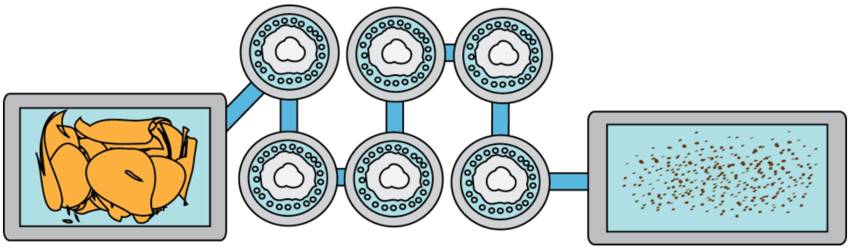

Figure 6. New configuration after the rearrangement.

9. After all of the experiments and adjustments we came out with the final value of COD shown in Table 3. We felt that the quality of the water was still not good enough, so we definitely had to do some more experiments.

Table 3. Final amount of COD for treated water from all system around the campus

COD (mg/L) (Oct 22, 2014)		
	IN	OUT
Patharapa Building	1319	149
Kitchen	999	209
Atitayakarn Building	1101	268

The second part was to reduce the quantity of used water. Even if we can efficiently purify wastewater, if we do not change the behavior of the users, the wastewater problem could still run on or even grew bigger. For instance, students could have used water too much so that it exceeds the limit of the system, causing the system to fail. For this reason, we have educated students about the negative effects of wastewater by taking students who study in Patharapa Building (Grades 7-9) to observe our water treatment system during their homeroom period. Likewise, we also persuaded them to decrease the use of detergents, because detergent is also an organic compound and can emulsify grease and water, which make it difficult for the system to trap the grease. When it is hard to trap the grease, it will of course go through to the aeration section, meaning more compounds for bacteria to digest, and more time required to get rid of all organic material.

Figure 7. Explaining the negative effects of detergent to students

Plans for the future.

We will continue to improve the treated water quality. We hope that treated water will be reusable for watering plants and washing the recyclable trash in the future.

Conclusion of what we have learnt

1. Skills
    - Critical thinking and analyzing
    - Ability to use tools and to work in laboratory correctly
    - Researching information
2. Knowledge
    - Measuring quality and volume of the water
    - Calculating quantity of chemical substance in the water
    - Basic knowledge of construction
    - The various types of systems and the processes of treating wastewater
3. Our growth
    - Concerned more about effects on the environment.
    - Having more responsibility
    - Increasing our analyzing ability

Appendix

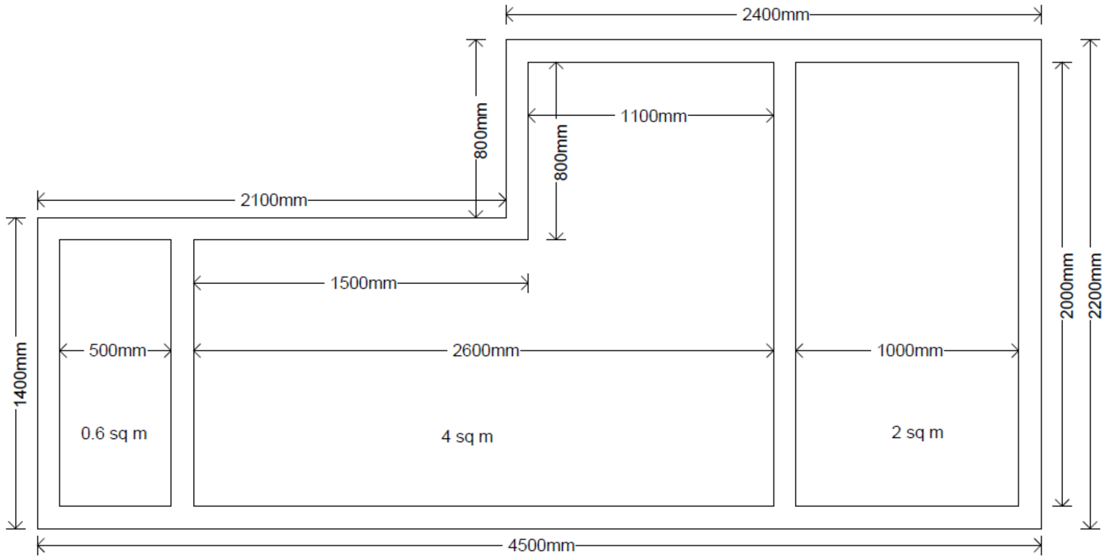

Figure 8. Our Construction Plan for The New Grease Trap Section (top view)

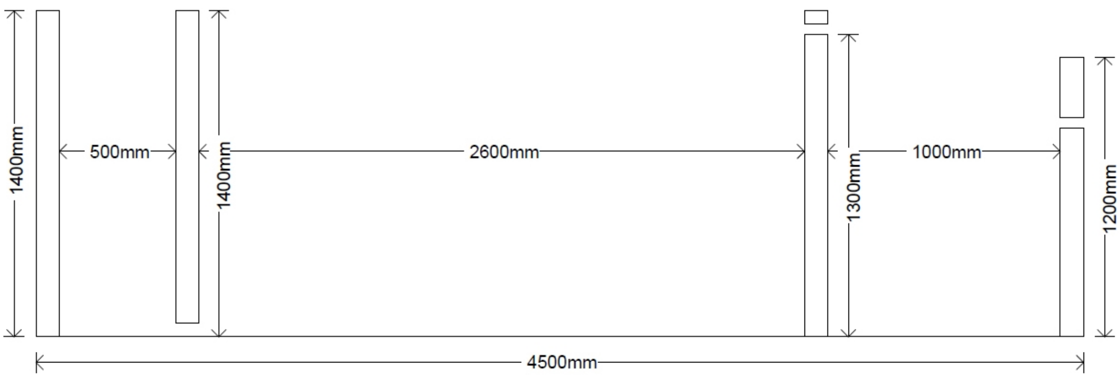

Figure 9. Our Construction Plan for The New Grease Trap Section (cross section)

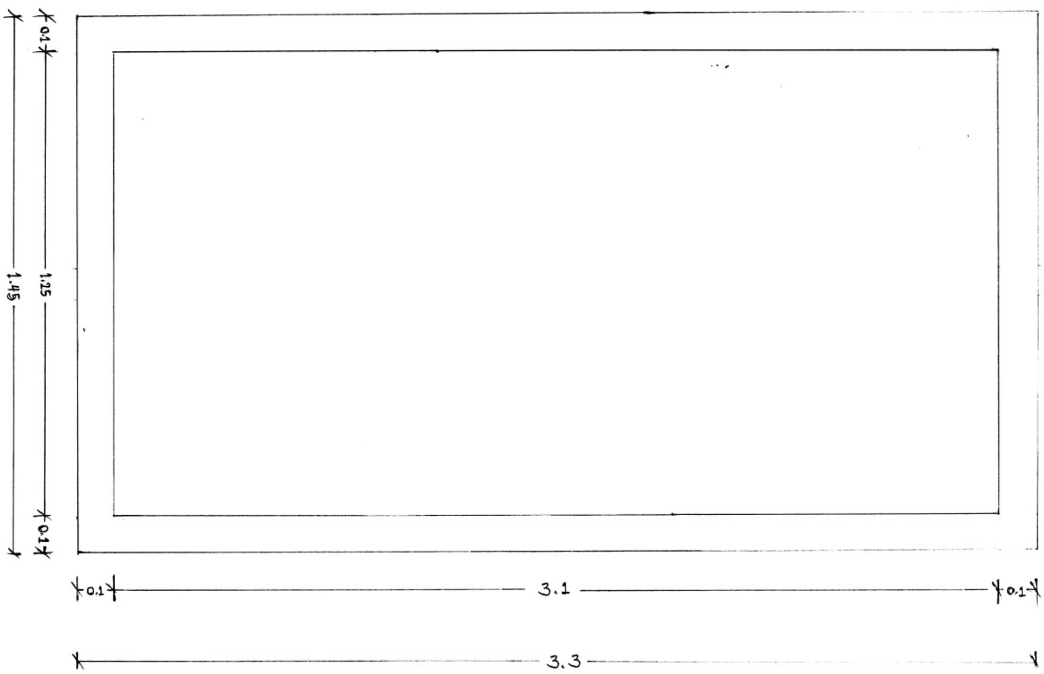

Figure 10. Our Construction Plan for The New Precipitation Section (top view)

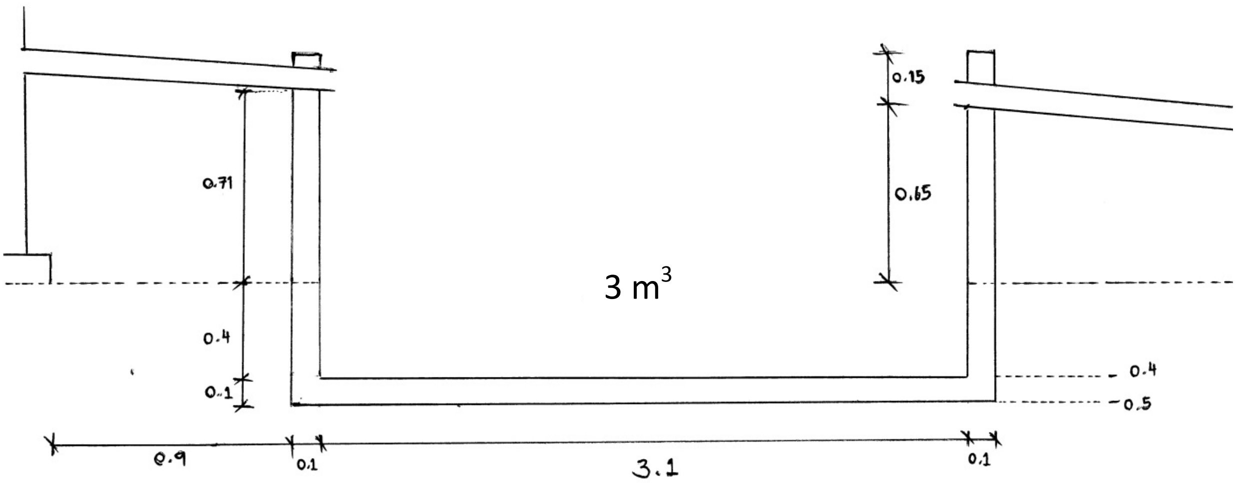

Figure 11. Our Construction Plan for The New Precipitation Section (cross section)

Table 4. Table of budget in THB (1 US$ = approximately 32 Thai baht)

Grease Trap section	8,000
Grease Trap roof	2,640
Precipitation section	4,800
Precipitation roof	2,425
Others	350
Total constructing material	18,215
Construction Crew Fee (Approx. 30% of Constructing material)	5,464
Total	23,680

TONGTHAI TAOTONG - I plan to attend King Mongkut University of Technology Thonburi in electronics and telecommunication field next year. My hobby is playing music, and making audio amplifiers and other electronics elements.

KITTINAN THANISSARANON - I enjoy reading novels and watching movies in my free time. I plan to attend an Aerospace Engineering program at Chulalongkorn University next year.

TANASIT TUANGCHAROENTIP - I like reading and watching videos about science. Next year, I plan to attend in faculty of Computer Engineering.

MONTIEN ATHIWORAKUL - In the future, I would like to study in international business major at one of the well-known college in Thailand, Mahidol University.

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