UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF INTEGRATED HYDROPONIC EMBEDDED WITH FLOATOVOLTAIC SYSTEM FOR CROPS CULTIVATION

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181914

A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR

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DEDICATION

This thesis is dedicated to

My Beloved Parent

Mailan bin Kamijan

Boirah binti Jemiran

My Siblings

Amron, Siti Rozana, Amran, Yusman,

Anifah, Surianti, Idris, Nurul Najiha, Nor Aishah

My in-laws

Amizat, Norashima, Che Mazwin, Suzana, Hakim

Hafiz, Fathima, Nizam, Ramzan

My nieces and nephews

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ABSTRACT

Floating photovoltaic systems is getting widely installed as results of land scarcity and encouragement to merge into renewable energy utilization. The available space under the floating PV has potentially to be utilizing for agrivoltaic purposes. This study is focused on redesign and reconstructs Floatovoltaic structure embedded with hydroponic system where a new integrated controller system is developed for embedded floatovoltaic system for crops cultivation to control water level. The vital parameter to evaluate the success of the systems is based on the yield crops by conducting a conduct field measurement of plant growth. The finding showed that the plant growth is following the market standard. The field measurement test involves observations, various points of thermocouple and humidity sensor throughout the experiment. The environment condition around the Floating PV is appropriate for hydroponic vegetable plant to be growth. The usage of solar energy for electricity and water from the ponds reduces the operating cost rather than using agrivoltaic system under the ground mounted PV.

ABSTRAK

Sistem PV terapung semakin banyak dipasang atas faktor kekuarangan tanah dan galakan dalam penggunaan tenaga boleh diperbaharui. Ruang yang ada di bawah PV terapung berpotensi untuk digunakan untuk tujuan agrivoltaik. Kajian ini memberi tumpuan kepada reka bentuk semula dan rekonstruksikan struktur PV terapung yang tertanam dengan sistem hidroponik di mana sistem pengawal bersepadu baru dibangunkan untuk sistem PV terapung yang tertanam untuk penanaman tanaman untuk mengawal paras air. Parameter penting untuk menilai keberhasilan sistem adalah berdasarkan hasil tanaman dengan melakukan pengukuran medan kelakuan pertumbuhan tanaman. Penemuan ini menunjukkan bahawa pertumbuhan tumbuhan mengikuti standard pasaran. Ujian pengukuran lapangan melibatkan pemerhatian, pelbagai titik sensor termokael dan kelembapan sepanjang eksperimen. Keadaan persekitaran di sekitar PV Terapung sesuai untuk tumbuhan sayur hidroponik untuk menjadi pertumbuhan. Penggunaan tenaga solar untuk elektrik dan air dari kolam mengurangkan kos operasi dan bukannya menggunakan sistem agrivoltaik di bawah PV yang dipasang.

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PV	Photovoltaic
Floatoponic	Floating PV + Hydroponics
TNB	Tenaga Nasional Berhad
PETRONAS	Petroliam Nasional Berhad
ICPT	Imbalance Cost Pass-Through
AAIBE	*Akaun Amanah Industri Bekalan Elektrik*
FiT	Feed in Tariff
LSS	Large Scale Solar
RE	Renewable Energy
NEM	Net Energy Metering
MESTECC	Ministry of Energy, Science, Technology, Environment and Climate Change
NFT	Nutrient film technique
DFT	Deep flow technique
SDG	Sustainable Development Goal
NPSHA	Net positive suction head available
NPSHR	Net positive suction head required

CHAPTER I

INTRODUCTION

1.0 Introduction

Electric dependency on fossil fuel is immense in few years back as increase in consumption in domestic, industrial, commercial and others. Tenaga Nasional Berhad (TNB), a company who solely supplied electrics to consumers, reported in 2018, the consumption of coal and natural gas to generate electricity is 55.86 per cent (51.86%) and 40.17 per cent (40.17%) respectively. A balance on fuel mix is needed to avoid electricity interruption as a result from depletion of fuel resources. The concern that highlighted is the cost to purchase the fossil fuel which increase annually. Most of the coal is imported from abroad, while, gas is mainly obtain from Petroliam Nasional Berhad (PETRONAS) and some also imported as Malaysia has limited sources. Based on annual report of TNB in 2018, fuel cost is RM 5.3 billion compared only RM3.3 billion in 2017. Imbalance Cost Pass-Through (ICPT) is implemented to cover the increase in average coal price. The increase affected the non-domestic customers which ICPT surcharge increase from RM1.35 sen/kWh to RM2.55 sen/kWh starting from 1 march 2019 (Tenaga Nasional Berhad, 2018). Subsidy allocation by government is specific for domestic customer below 300 kWh of consumption however above 300 kWh of consumption, ICPT surcharge will be funded by *Akaun Amanah Industri Bekalan Elektrik (AAIBE)*(Tenaga Nasional Berhad, 2017b).

The environmental pollution that cause from the huge use of fossil fuel is another key issues considered by all mean the usage of fossil fuel must be deplete. The largest gasses that emitted to environment are carbon dioxide (CO_2) where it can cause global warming. Based on the environment statistic release by Department of Statistical Malaysia, the pollutants emission to atmosphere by source in 2017, motor vehicle recorded the highest per cent of emission (70.4%) followed by power plant which contribute the second largest emission

(24.5%), industrial (2.9%) and others (2.1%) (Department of Statistical Malaysia, 2018). To curb these, Malaysia needs to optimize the usage of renewable sources to reduce cost and pollutions.

To reduce the consumption of energy, the government has introduced a renewable and efficient energy initiative such as Feed in Tariff (FiT), Large Scale Solar (LSS) and Net Energy Metering (NEM), which in 2025, 20 per cent (20%) are expected to be generated from Renewable Energy (RE). Currently, the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) promoting the third Large Scale Solar (LSS3) for open bidding to reduce cost, which could generate up to 100 M. It is leading to increase the renewable energy mix in electricity supply, thus decreasing utilization of fossil fuels, as well as decreasing greenhouse gas emissions(MESTECC, 2019). The initiatives include using Solar Photovoltaic to generated electricity which has relevant exchange in term of cost and offset basis. The utilization of renewable energy is getting better as many researches and development is enthusiastically takes place in university as well as government and non-government agencies.

A photovoltaic system is a technology that rapidly growing worldwide and had frequent improvement done to increase the efficiency. The photovoltaic system is comprised of solar photovoltaic cells that go through a process of converting sunlight to direct current electricity. This type of Photovoltaic is mounted on ground or building which needs large space to produce higher electricity. An example of ground mounted solar is first Large Solar Scale (LSS1) in Kuala Langat, Selangor conducted by TNB had used 98 hectare of land for PV mounting which contributing 73.2 MW (Tenaga Nasional Berhad, 2017b).

Opposed from the advantages listed, the main challenge faced by LSS developers is land availability whereby they have to discover huge flat land that accessible for project site with power purchase agreement for duration of 21 years. Additionally, the land use zoning regulation also have given confusion to developer as LSS plant location is categorized in industrial or other categories of land use are tolerable. The developer claims that LSS plant has no major impact to environment, thus not need to be located on industrial land (ZICO LAW, 2017).

Floating photovoltaic (FPV) system or known as floatovoltaics, is the latest innovation that evolving technology of photovoltaic system in which positioned directly on water rather than on land or building. The driving factor for development of floatovoltaics system are competing uses of land and the advantages associated with installing floatovoltaics on water. Existing studies on the performance of floatovoltaic are satisfying even there is still immature research outcome. The system experience better power conversion efficiency gains due to lower ambient temperature beneath the panels, irrespective of whether the panels are directly or indirectly place on water. Power production gains documented is 1.5% to 22% which due to the cooling effect on floatovoltaics (Spencer, Macknick, Aznar, Warren, & Reese, 2018).

TNB subsidiary company Tenaga Nasional Berhad Research (TNBR) is embarking a research on the development of country's first floating solar project that is being started in Sepang, Selangor by utilising the Malaysia Electricity Supply Industries Trust Account (MESITA) funds. The project is launched in March 2015 in Sungai Labu Water Treatment Plant (WTP) with a capacity of 108kWp, covering 1,000 m^2 on 50 hectare lake. The research is expected to cover lot of open water area such as lakes, reservoirs, and water catchment area (Tenaga Nasional Berhad, 2017). Additionally, around 70 lakes in Peninsular Malaysia are found suitable for developing floatovoltaics system. Apart from that, the idea of encouraging floatovoltaic system can reduce land usage as the priority of land is for agriculture purposes. Besides, by lowering the temperature of water bodies, evaporation of water can be minimize and reduce the area that exposed to sunlight (The Malaysian Reserve, 2019).

The other potential idea to be implemented to optimize the floatovoltaic space is by imbedding the hydroponic system underneath the floatovoltaic structure. Hydroponic system mainly using water to grow crops and some crops can withstand extreme weather and surrounding like Chinese cabbage (Pak Choy), Rex (Butterhead lettuce), and Nevada Summer Crisp lettuce (Ferguson & Omaye, 2015). Furthermore, three (3) techniques that commercially being used to grow plant hydroponically which is deep flow technique (DFT), nutrient film technique (NFT), and aeroponic system. It is convenient planting method especially for growing leafy vegetables whereby on food perspectives, it could lead to food sustainability objective (Son, Kim, & Ahn, 2016).

1.1 Problem Statement

The depletion of the availability of land causes conventional agriculture system become uncompetitive as the price of land increase gradually Putera et. al. 2015). The alternative way to cater this issue is by utilizing water area such as lakes. Malaysia has good source of water like water catchment area, lakes, reservoirs to supply food and clean water for communities, agriculture, contribute significantly to Malaysia's economy and provide basis for natural environment (Suhaily, Che, & Othman, 2010). Based on Review of National Water Resource Study 2000-2050 for water resources in Malaysia, annual rainfall recorded is 971 billion m^3, Surface runoff is 494 billion m^3, 64 billion m^3 for groundwater, and evaporation transpiration – 413 billion m^3. Excess evaporation might occur at open area water source cause unpredictable climate which driven to water scarcity (Lim Chow Hock, 2008).

In Peninsular Malaysia, TNB claims that almost 70 lakes are potentially used for alternative purposes and had triggered TNBR to unveiling floatovoltaic based on the benefit resulting satisfied. The positive impact of its performance owing to the shading effect, reduction in algae growth, reduced sunlight penetration; lower water temperature (Sahu, Yadav, & Sudhakar, 2016). Recent research outcomes claims that Floating PV reduce water evaporation from reservoirs. The way floatovoltaic is installed by mounting modular crystalline PV panels at an optimal tilt on top of individual pontoons. The gap under PV panel and water is not fully optimized (Kim Trapani, 2014)

Borhanazad et. al. (2018) states that around 3.8% of the population in Malaysia lives under the poverty line and discovered that some are from rural area. In 2009, Sabah records higher poverty percentage and listed as poorest States in Malaysia which is 19.2%. Bumiputera, who are living in less settled States of Malaysia with emphasis on agriculture sector are in the majority of poor people. The challenge face by them is lack of electricity and energy poverty. This can cause inconvenient for a family especially for education of their children if electrical supply is not enough. Around 1000 people of *Orang Asli* is reported having electricity difficulties in Kampung Pos Hendrop, Gua Musang, Kelantan and urge the government to supply 24 hours electricity for them (Astro Awani, 2019).

Other issue prone to poverty is nutritious food supply which most of them have least nutrient uptake which only having staple food like rich and tapioca. In the perspective of food sustainability issues, based on Sustainable Development Goal (SDG), the second goal targeted is zero hunger whereby the poor and vulnerable people have enough, safe, and nutritious access to food a year. It also emphasize on improvement of nutrition intake in food and toward the end of malnutrition cases especially in children, women, and older persons. Thus, to realize the goal, the agriculture productivity have to be expand and more operative food market (Unit, 2017).

1.2 Research Rationalization

This project is to highlight the solution for this community to obtain sufficient electricity and nutritious food by using an integrated floatovoltaic system.

Table 2.0: Previous study on Solar PV with agriculture

No	Topic	Type	Year
1	Floating Hydroponic Crops Proposal Tonle Sap Lake, Cambodia (Vladimit BOC, Ioana STREZA)	Journal	2014
2	Development and Evaluation of Solar-Powered Instrument for Hydroponic System in Limapuluh Kota, Indonesia (Perdana, Novita et. al)	Journal	2015
3	Towards Commercial Aquaponics: A Review of Systems, Design, Scales and Nomenclature (Harry W. Palm et. al)	Journal	2017

1.3 Objectives

This project is targeted to project a The Floatovoltaic Dryer is to be equipped with the hydroponic system for in situ farming. The system expected to grow crop hydroponically under the Floatovoltaic to optimize the space beneath and names as **FLOATOPONIC.**

Objective of the project are to:

- Redesign and reconstruct Floatovoltaic structure embedded with hydroponic system
- Develop a new integrated controller system for embedded floatovoltaic system for crops cultivation to control water level.
- To conduct field measurement of plant growth based on water level inside hydroponic system as feedback control.

1.4 Project Scope

Project scope is defined to follow such designations, where constriction will be applied while relevant.

- The reconstruct structure is taken from previous project structure which is 800W Floatovoltaic Dryer.
- The growing tube can successfully cultivate hydroponic tube by using pond water
- The system consist of automated water pump connect to level switch to closed the circuit.

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

This chapter comprise of research related to the problem solving where it can be used for further research on the system required to conclude the project's requirement. Details on basis of the system theory and equipment may be justified on this chapter. The contribution from relevant research may be support to discuss appropriate methodology in Chapter 3: Methodology.

2.1 Overview

Hydroponic embedded with Floatovoltaic system or Floatoponic is intended to help less fortunate people in rural area to obtain electrical supply as well as to provide nutritious food like leafy vegetable. It is comprises of two system which is photovoltaic system to provide electricity to turn on pump system, and hydroponic system to grow the selected crops. The overall goal of this project is to make a prototype nevertheless pertinent for practical uses which could be install in selected area to benefits the community.

The Floatoponic will be equipped with integrated control system for crops cultivation to control water level, which level sensor or level switcher is place at fix point in the growing tube. The level sensor then connected with pump. The floatovoltaic system applied off-grid system where electricity is store inside 14V battery to supply 24 hours electricity to pump system to operate when circuit is closed. Nutrient for hydroponic will be filled manually and monitor frequently to maintain the nutrient value using unit of electrical conductivity (EC). Data logger system also installs to measure the water flow rate that pump into growing tube. Besides, it recorded the fundamental environment data such as temperature, and humidity to consider whether the environment apposite for hydroponic.

2.2 Floating Photovoltaic System

The Floating PV is a new concept with only few demonstrator projects worldwide. The example countries demanding the floating PV are Japan, USA, Korea, Australia, Brazil, India and others. It was installed in water bodies like oceans, lake, lagoons, reservoir, irrigation ponds, waste water treatment plant, etc. Around 4-18% of incident solar energy was converted into electricity by typical PV module, depending on the type of solar cells and climatic condition (Sahu et al., 2016).

The available floatovoltaic structure used commercially is using pontoons as the buoy where modular crystalline PV panel with optimal tilt mounted on it. Based on structure proposed by Thomson Technology walkaway structure on the Floatovoltaic is included in between raw off panels and along the side for maintenance and cleaning. Trapani (2014) claims that, by using pontoons and the PV panels on reservoir, evaporation can be deplete. Different with Floatovoltaic in Italy, the floating medium used is hollow polyethylene cubes at the two opposite edge and strut for the PV panel are mounted through it.

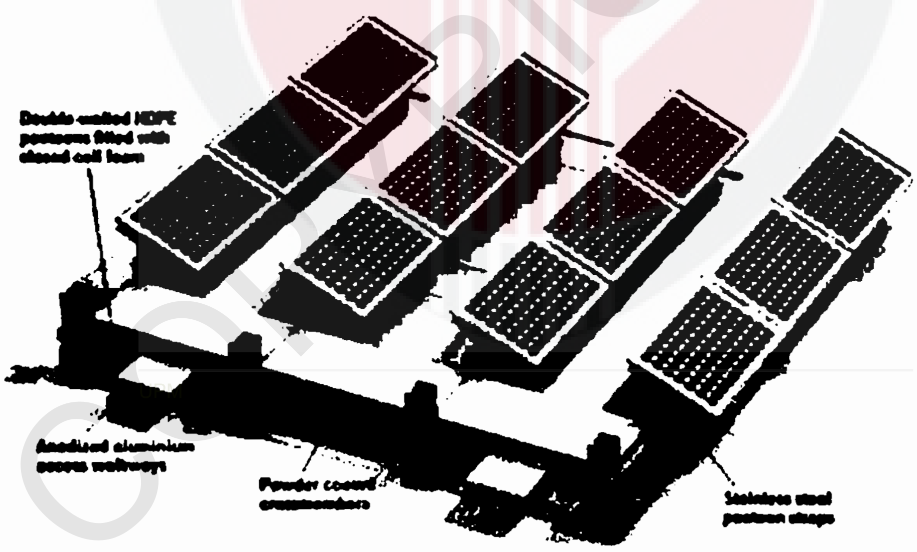


Figure 2.1: Floatovoltaic structure proposed by Thomson Technology (Kim Trapani, 2014)

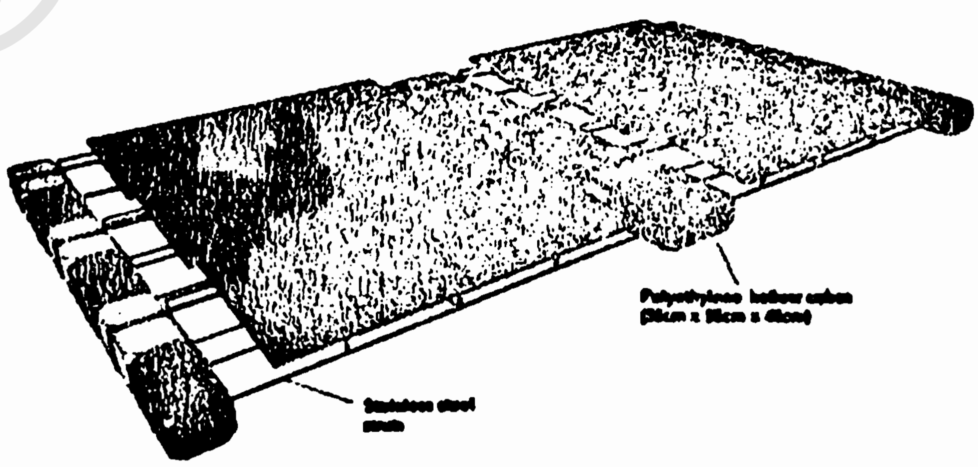


Figure 2.2: Floatovoltaic structure install in Bubano, Italy (Kim Trapani, 2014)

Based on study done by (Osman, Ya'Acob, & Iskandar, 2017), the floating photovoltaic structure is modified by placing rectangular frame under the solar panel for drying purposes where the type of solar used is flexible solar panel that installed in an arc shape while the buoy is using 160 mm PVC pipe with dimension 1 m x 1.75 m. Based on Figure 2.4, Majid et. al. (2018) design a simple floatovoltaic consist of three components which are Polyvinyl Chloride (PVC) pipe as buoy, hollow square aluminium as heat sink and solar panel for power generator. The PVC pipe used for both design is to trap air such that it will float on water.

Figure 2.3: Floatovoltaic structure that modified for drying purposes. (Osman et al., 2017)

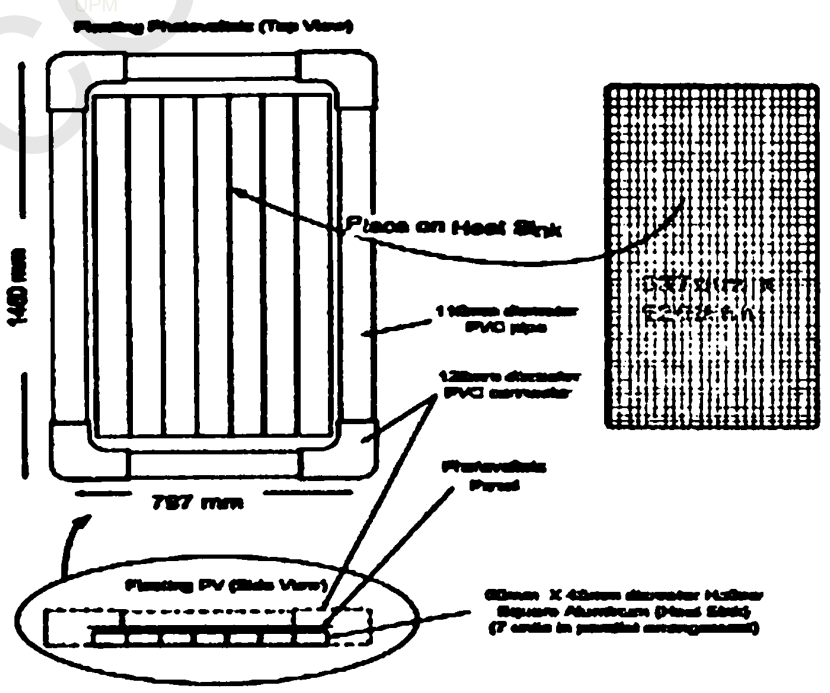


Figure 2.4: Proposed design of 80 W floating photovoltaic (Majid, Ruslan, Sopian, Othman, & Azmi, 2014)

2.3 Hydroponic

Hydroponic systems or hydroponics is a method of using mineral nutrient solution in water instead of using soil medium. There are two common type of hydroponic system used for growing leafy vegetables which are deep flow technique (DFT) and nutrient film technique (NFT) (Son et al., 2016). In the DFT system (Figure 2.5 (a)), the water will be supply o the plants whenever the water level in the culture become lower than the set value, and are recirculate and supplied to the bare roots of plant, at constant time intervals, into the culture bed with a 1/100 slope.

NFT systems (Figure 2.5 (b)) was developed by Dr Allan Cooper whereby the system using a thin film of nutrient solution flows through plastic channel, which contain the plant roots with no solid planting media. The root mat developed partly in the shallow stream of recirculating solution and partly above it. The example of plant that can grow well in hydroponic NFT system is Pak Choy (*Brassica chinensis* L.) (Hussein, 2018). Other than that, the sensor for root-zone environment factor (nutrient concentration, pH, Dissolved oxygen, and temperature is needed for real-time measurement (Son et al., 2016).

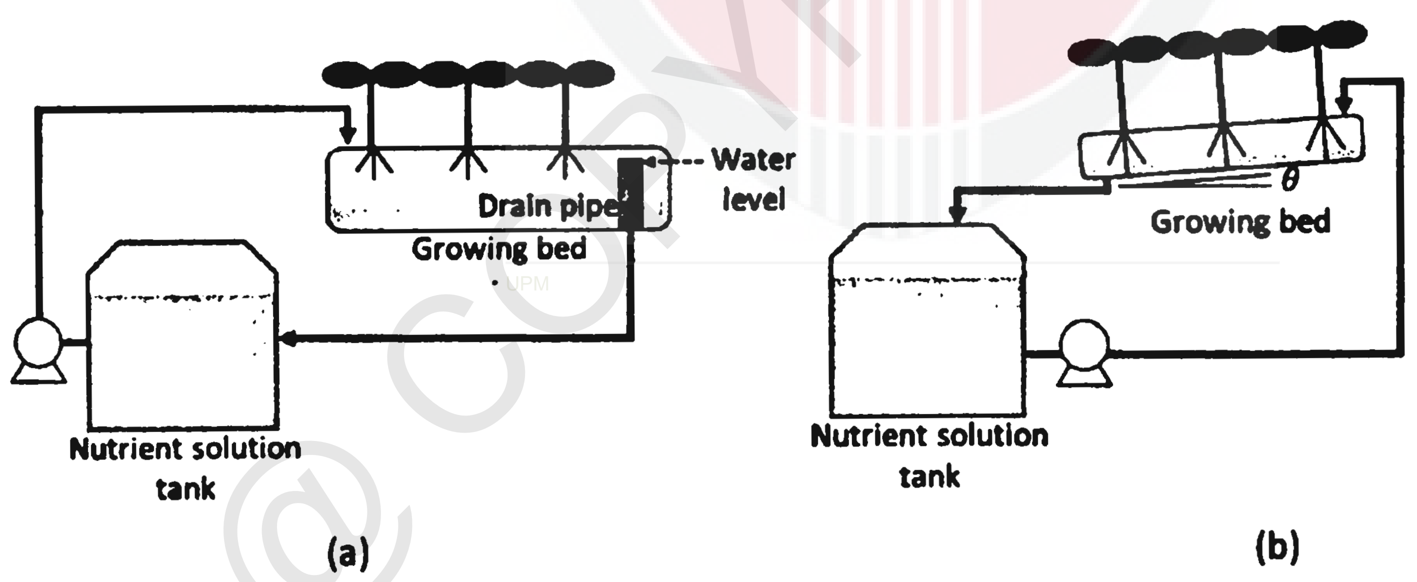


Figure 2.5: (a) Hydroponic DFT system and (b) Hydroponic NFT system (Son et al., 2016)

Table 2.1: Comparison between DFT and NFT

Aspects	Deep Flow Technique (DFT)	Nutrient Film Technique (NFT)
Control system	Feedback control	Feed-forward control
Operating Time	Below set point level	24 hours
Operating cost	Low -Not relying on pump	High -For operation of pump
Effect on vegetative growth	Better	Normal
Slope	0 %	2-3%
Pump dependence	Low	High

Based on Table 2.1, the comparison is obtain from different research finding where the selection for suitable technique not just based on the yield but also considered on the maintenance and operational preference (Walters et. al., 2015). Study conducted by Maneeply et. al. (2018) on cultivation of Brahmi (Bacopa monnieri (L.) Wettst) in two different systems which are DFT and NFT for comparison based on plant growth. DFT resulted better performance on plant growth, which produced more number of auxiliary shoots. Plant leaf number and leaf area also higher if plant is grew in DFT compared to NFT.

2.4 Favourable Type of Crop for Hydroponic

Selecting vegetable plant that suitable for hydroponic is vital to make sure the plant can survive in the extreme environment such hot day or even high humidity environment. A distinctive crop cultivated is Chinese cabbage (Pak Choy), mustard, lettuce, celery. Zaini (2018) states that lettuce has higher revenue as it has higher selling price and farmer planted more than other types of vegetable.

Pak Choy is one the most suitable plant to grow in hydroponic as it can withstand extreme weather. The selection of plant also based on the growing period until it is matured where Pak Choy will takes 30 days after transplanting the seedlins in growing media.

2.5 Floating Photovoltaic Example

Vladiamir (2014), proposed on Floating Hydroponic Crops in Tonle Sap Lake (Figure 2.6)., Cambodia as the aim of it to provide continuous food supply chain. The floating hydroponic is powered by solar panel to circulate that water. Aspart from that, the material used as the growing compartment is recycled good like bottle. The photovoltaic system just mainly for the water circulation purposes not exceed until can supply the electric for communities around Tonle Sap Lakes.

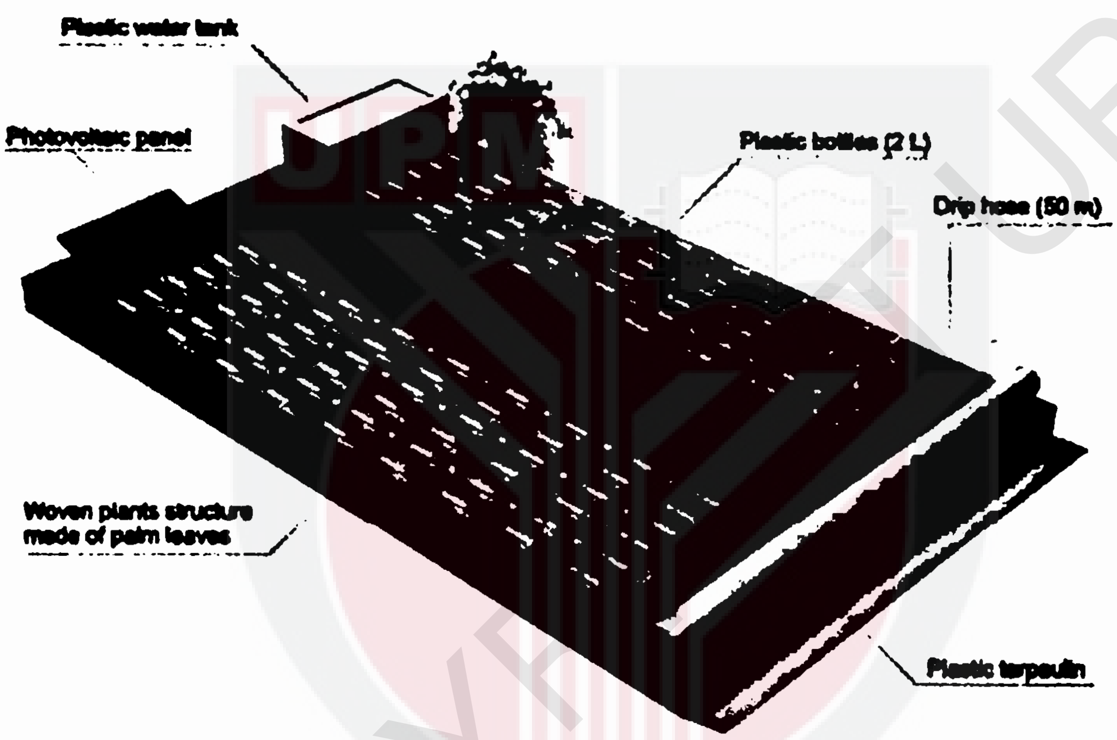


Figure 2.6: 3D modelling of Floating Hydroponic proposed by Vladiamir (2014)

2.6 Fertigation system

Fertigation is a combination of two words which is 'fertilizer' and irrigation. (Kafkafi, 2018). Typical fertigation system for hydroponic cultivation is using closed system where a nutrient (A and B mix fertilizer) is diluted inside a tank. Steidele Neto et. al. 2014 is applied Fertigation Automatic Control (FACS) where the core for this system is based on estimates of crop transpiration and leachate concentration. The system used closed loop controller by receiving from estimated or measure variable. 32 W small fertigation pump is used to distribute the nutrient solution to crops.

2.7 Data logger system

The experiment conduct by (Putera et al., 2015) shows that, the hydroponic system of solar powered instrument consists of solar cell, solar charge controller, battery, inverter, temperature and humidity sensor, solar tracker system and hydroponic system.

The data logger was set up in order to sustenance this project to interrelate the environment conditions and the growth of crops (Carre & Williamson, 2018). M. H. Abdullah (2017) proposed a design open source microcontroller based temperature data logger to implement it in industrial sector. The prototype that powered by 5V was armed with open source Arduino microcontroller for integrating multiple thermocouple sensor with their module, secure digital (SD) card storage, liquid crystal display (LCD), real time clock and electronic enclosure made of acrylic. It was claimed to be an economical system yet full-bodied with 8 channels computing element with capabilities to monitor and store real time data.

Figure 2.7: Prototype set up by M. H. Abdullah (2017)

It is very important to set up the data logger correctly in order to obtain an accurate data with accurate system and component.

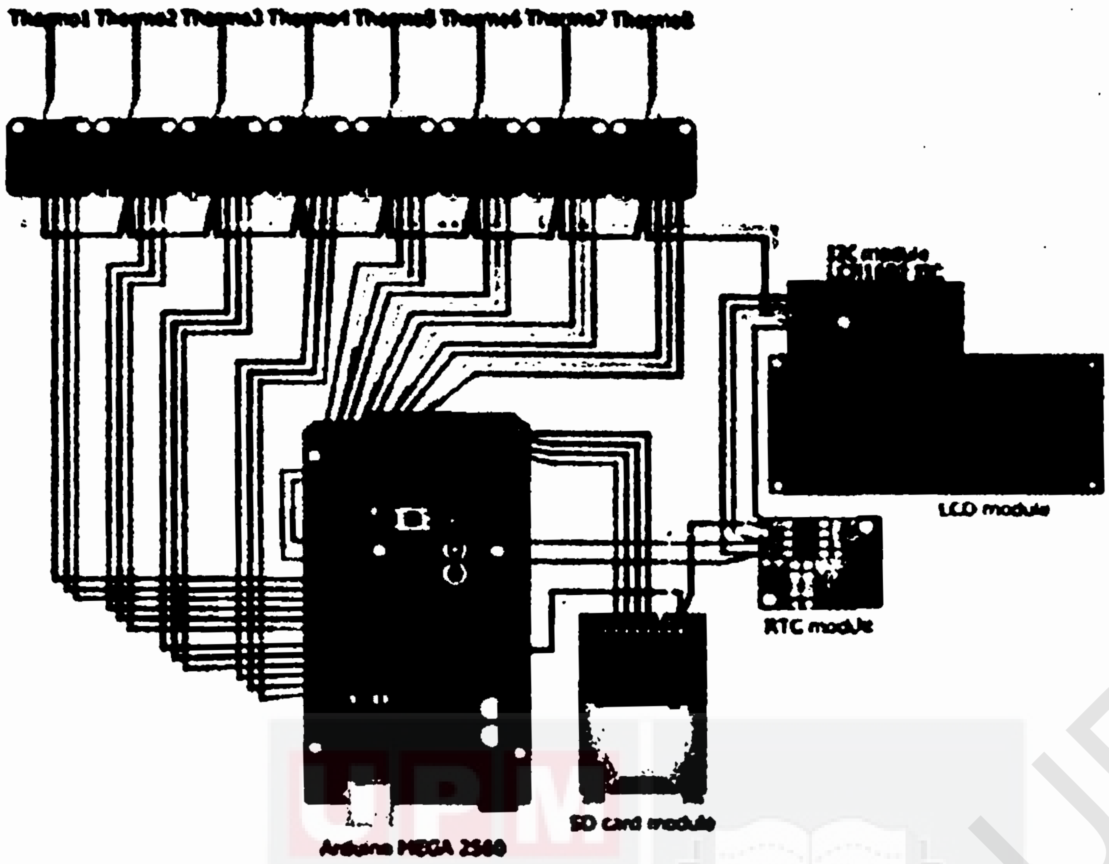


Figure 2.8: Example of wiring diagram for data logging system (Abdullah et. al. 2017)

CHAPTER III

METHODOLOGY

3.0 Introduction

The design procedure used throughout the project is research, planning, design, building, testing, combining, and verification. This chapter will conclude the strategy needed to provide prototype of Floating PV integrated with hydroponic (FLOATOPONIC), by redesign phase, restructure phase, crops preparation phase, control system development phase, and experimental phase.

Design phase will require making some modification on the previous version of 800 Wp Floating PV design to suit with the objective. Next, the construction phase is to execute the designated structure. Meanwhile, the crops are prepared in order to stabilize it for 2 weeks before transferred into Floatoponic. The development of control system takes place after the prototype is ready to be tested. Along experimental phase, the crops are monitor frequently and temperature, humidity and flow rate data is collected.

3.1 Research Execution Plan

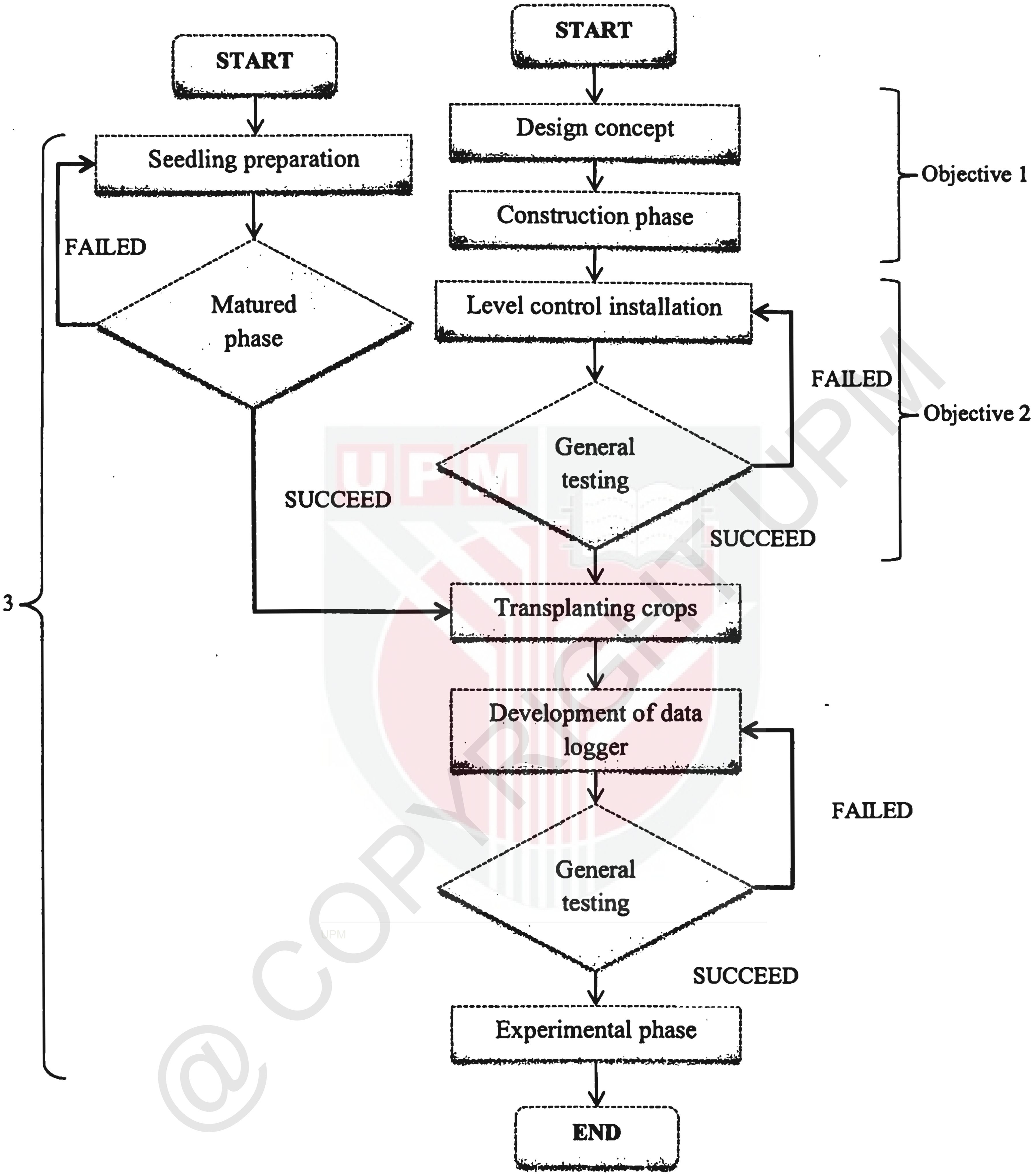


Figure 3.1: Project general flow chart

3.2 Design Concept

The objective of design drawing is to provide a detailed record and design of the project, and to establish standards for documenting the design, tendering, and construction process. Hence, the design of Floatoponic must following the objective mentioned.

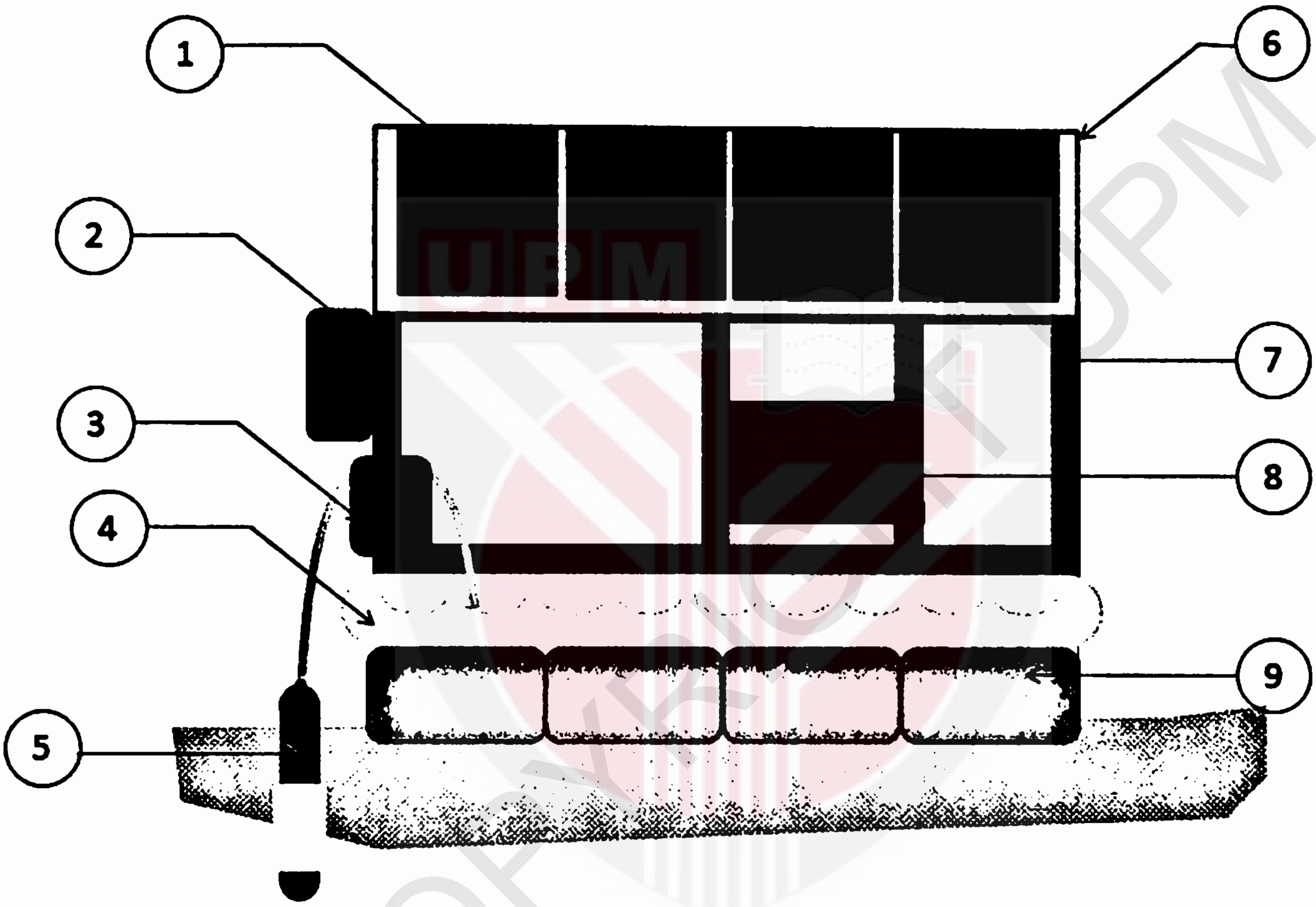


Figure 3.2: Designed drawing of Floatoponic

Table 3.1: Details of each component

No	Section	Specification	Dimension
1	Photovoltaic panel	Monocrystalline silicon laminated with TPT backsheet, includes aluminum grommets	1.06 m x 0.540 m x 0.003 m
2	Meter box	-	-
3	Pump	70W Micro high pressure diaphragm pump	-
4	Growing tube	Polyvinyl Chloride (PVC)	1.56 m x 2.34 m

		pipe	
5	Filter (large particle)	80 mm Polyvinyl chloride (PVC) filter	0.8 m x 1.3 m
6	Aluminium plate	3003 Aluminium plate	1 m x 2.13 m 0.001 m
7	Slotted angle iron	Galvanized Steel	0.89 m x 1.24 m x 2.13 m
8	Battery	Gel 100-12 12 V 100Ah/20HR	0.41 m x 0.18 m x 0.25 m
9	Pontoon	HDPE Modular Pontoon	0.50 m x 0.50m x 0.40 m

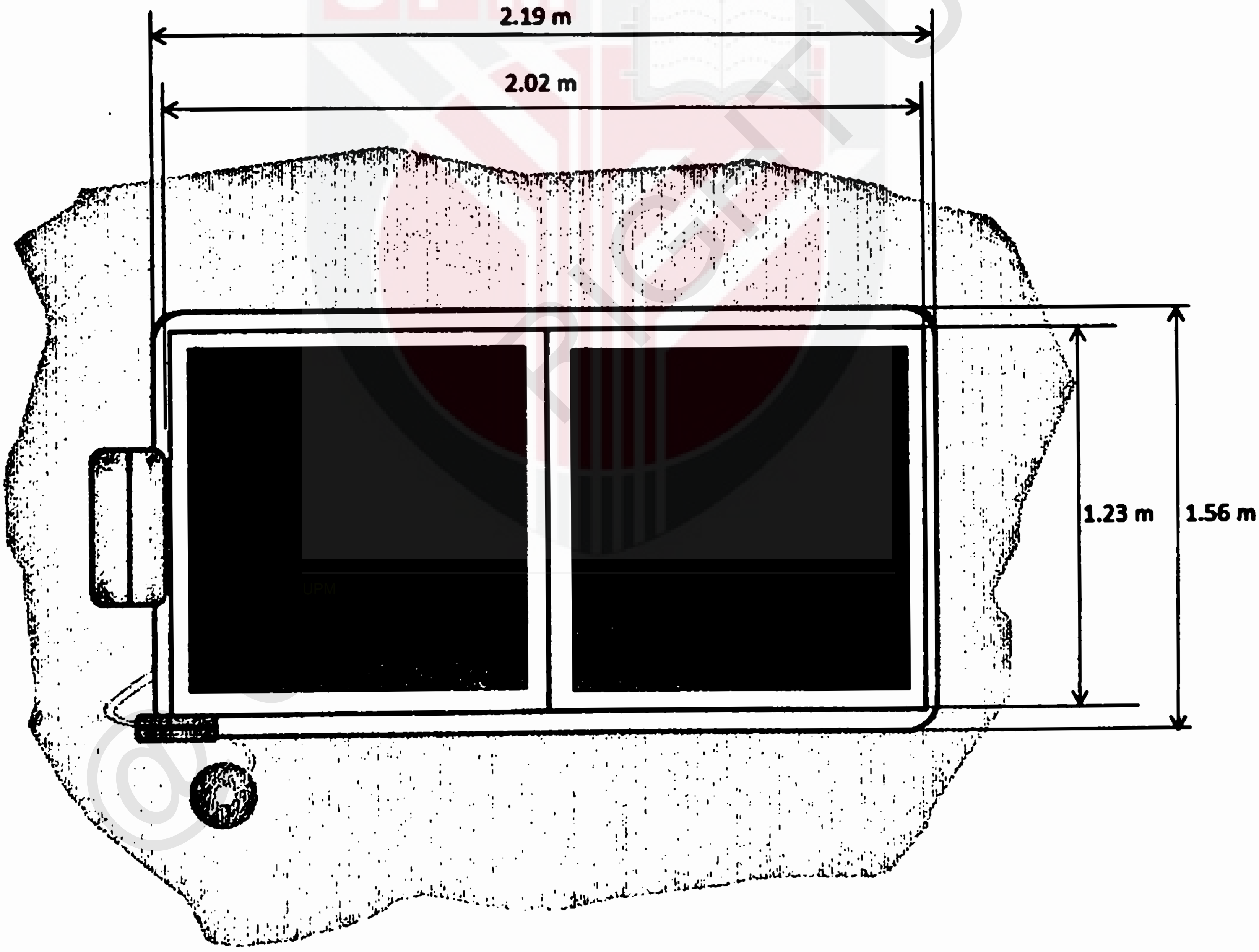


Figure 3.3: Top view of designed drawing of Floatoponic

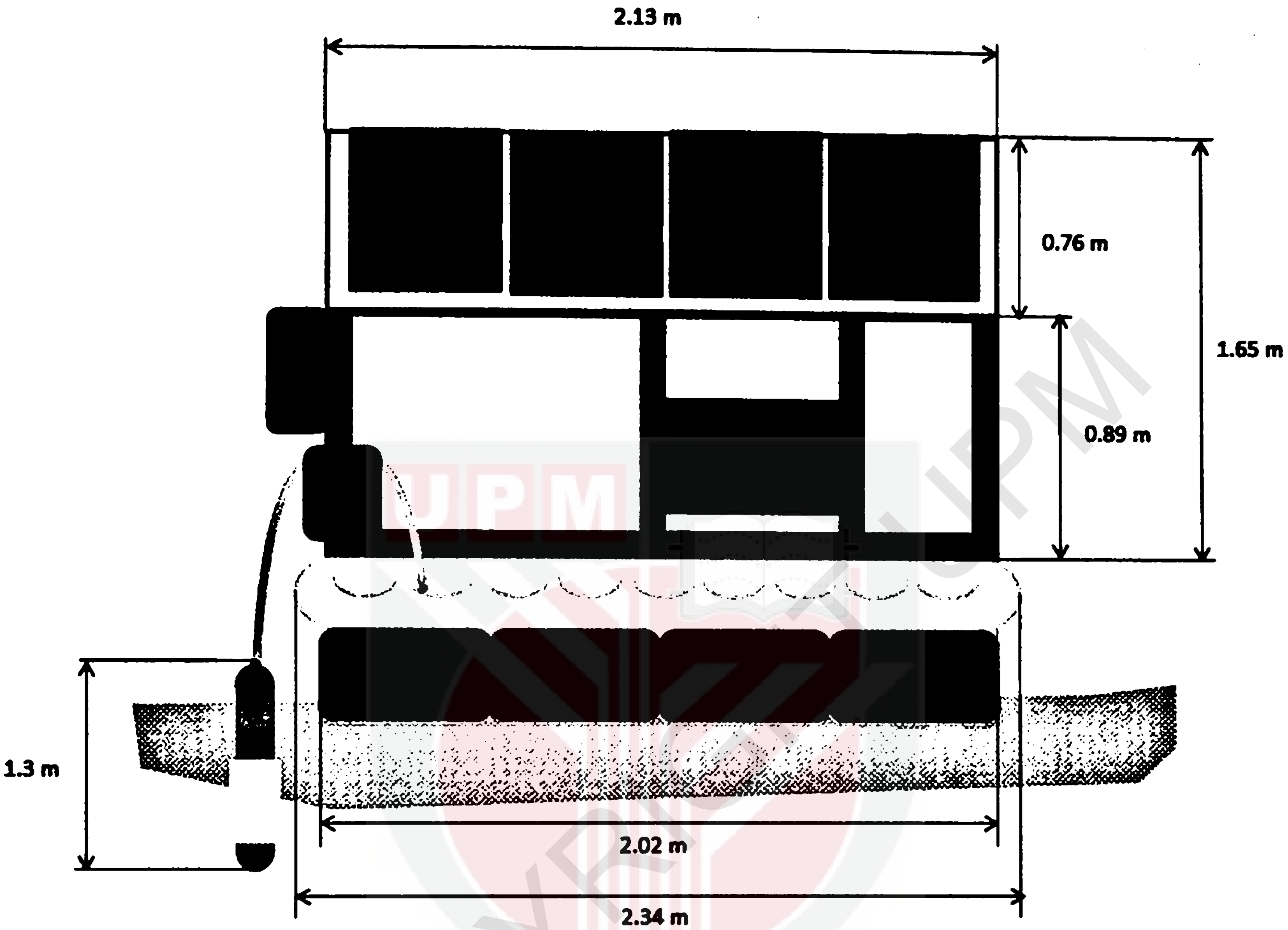


Figure 3.4: Side view of designed drawing of Floatoponic

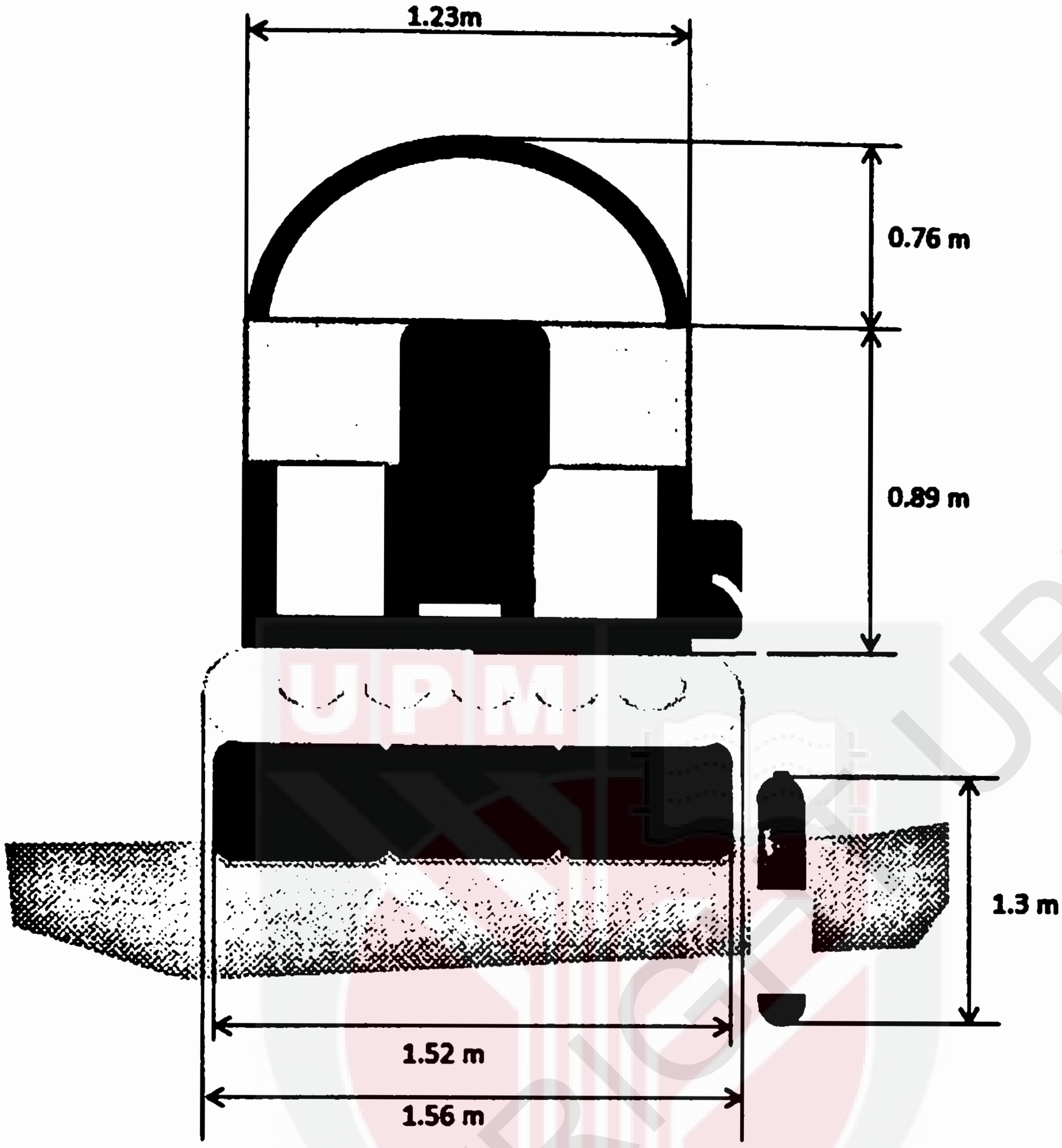


Figure 3.5: Front view of designed drawing of Floatoponic

3.3 Construction Phase

The overall components 800 Wp Floating Photovoltaic Dryer is initially disassembled and the component is used to construct the Floatoponic. The major elements in Floatoponic include frame, solar panel, hydroponic growing tubes, wiring, level sensor, pump, water level system and water filter.

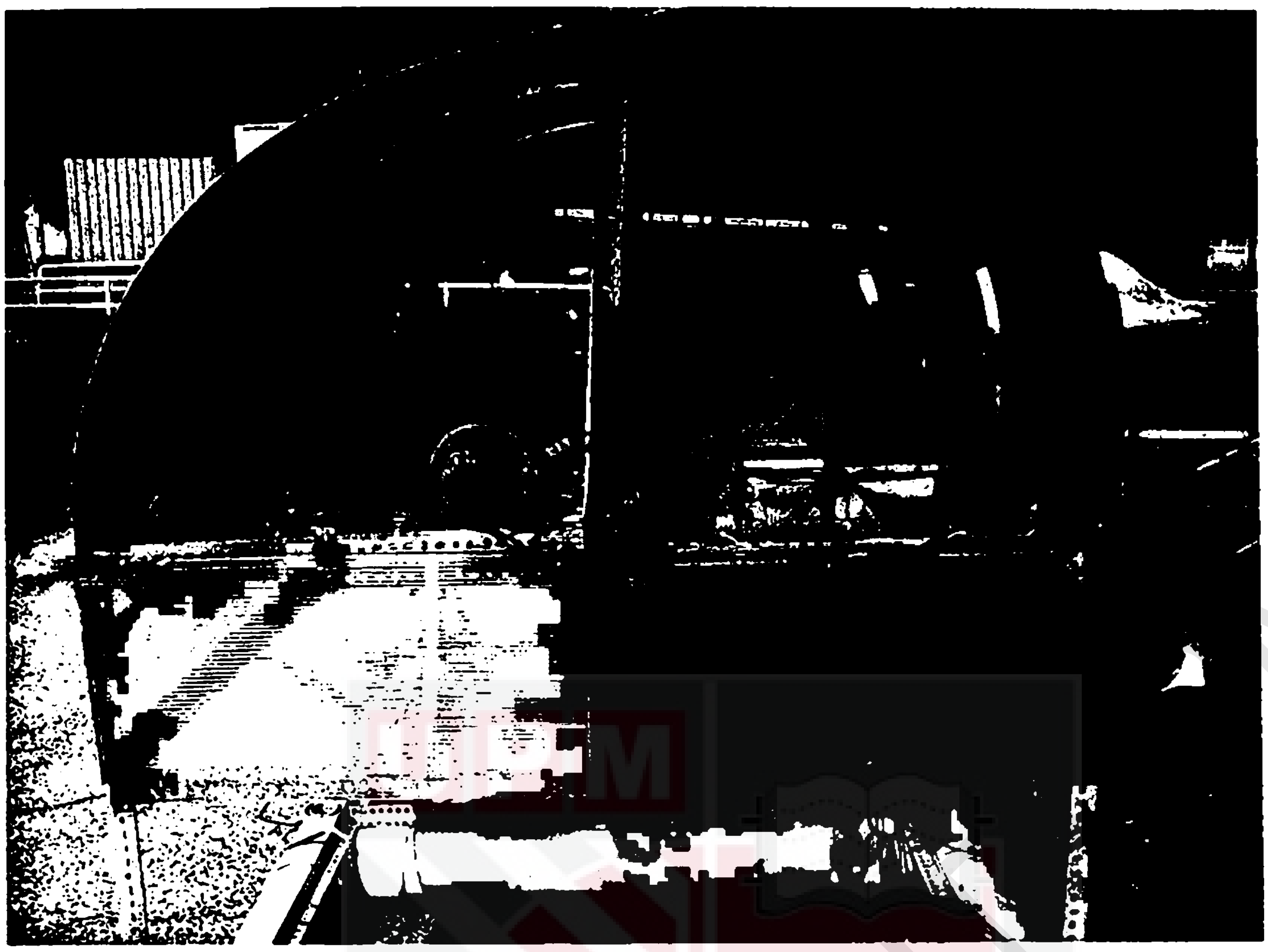


Figure 3.6: Floating PV Dryer

3.3.1 Frames

To reduce the cost to manufacture new base frame, the existence base frame is disassembled and painted using anti-rust paint to avoid rusting. Material used in is galvanized steel slotted angle. Advantages of this material is cheaper than stainless steel, reliable based on coating life and performance as well as have long life as it go through hot dip galvanizing. The dimension of the frame as shown below:

Table 3.2: Dimension of frame

Details	Dimension (m)
Height	0.889
Width	1.240
Length	2.130

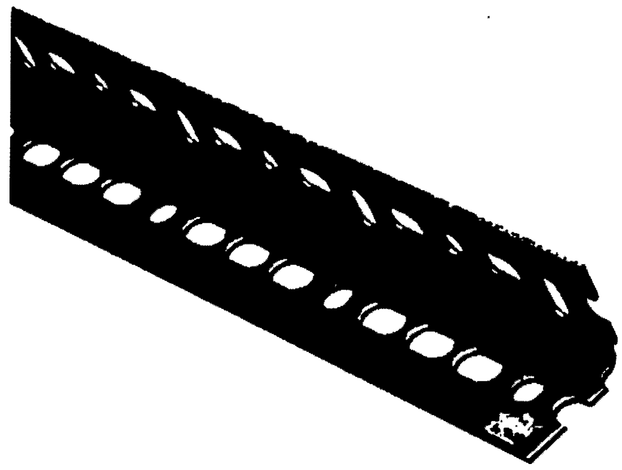


Figure 3.7: Galvanized steel slotted angle

3.3.2 Solar Panel Support

Additional of support under the solar panel is very crucial to make sure the solar panel can maintain the arc shape and to avoid it from break that cause from strong winds. The material selected is aluminium plate where it also acts as heat sink, flexible, excellent corrosion resist, and workability. The thickness of aluminium sheet is 1 mm.

Table 3.3: Details on solar panel installation

Component	Material	Specification	Dimension
Aluminium plate	Aluminium	-	2 x 86.67 inch x 24 inch x 0.039 inch 1 x 86.67 inch x 36 inch x 0.039 inch
Flexible Solar Panel	Monocrystalline	*Maximum power:* 100 W *Maximum voltage*: 18 V *Maximum current:* 5.55V *Open circuit voltage:* 21.6 V *Closed circuit Current:* 6.1 A	8 x 41.34 inch x 21.26 inch x 0.118 inch

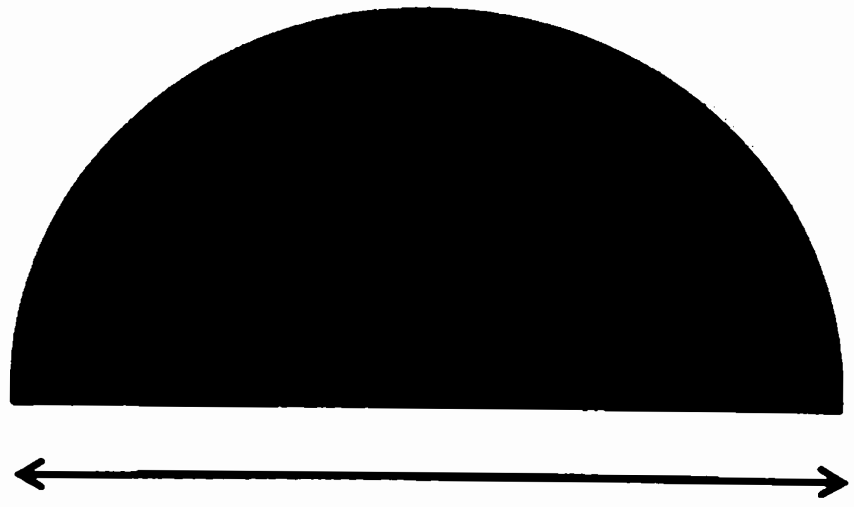


Figure 3.8: Diagram of angle bent

3.3.3 Hydroponic growing tube

The growing tube used is made of polyvinyl chloride (PVC) pipe where reuse from previous model and 50 mm – holes are drilled to put the growing pot. The dimension of the growing tube is 1 m x 1.75 m where distance between holes to holes is 40 mm. Expected holes obtain after calculation is 56 holes which equal to 56 crops can be grow. The holes is drilled at 45 degree position as shown in Figure 3.9, which it will make sure the plant can obtain enough sunlight and avoiding it from touching the frame.

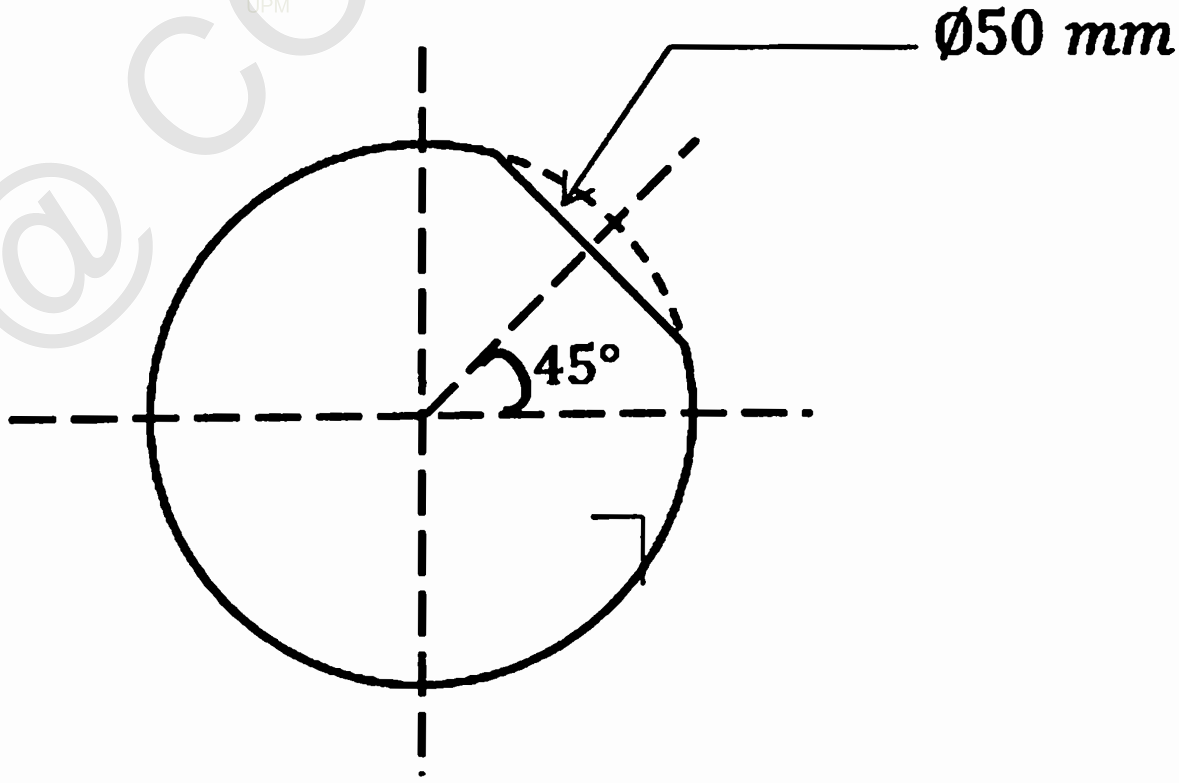


Figure 3.9: Cross section drilled hole

3.3.4 Wiring

Correct electric wiring is vital to avoid shortage. The electric is used to generate pump to flow-in the water into the growing tube. As mention previously, the photovoltaic system is using off grid system where the excess energy will store in battery. The solar panel module is assign in parallel connecting. The positive terminal is connected together and the negative terminal also connected together (Figure 3.10). Purpose of this to make sure the voltage remains same but the output current will be sum up. The solar module, battery and load of positive and negative terminal will connect to solar charger controller to flow the electrical power accordingly.

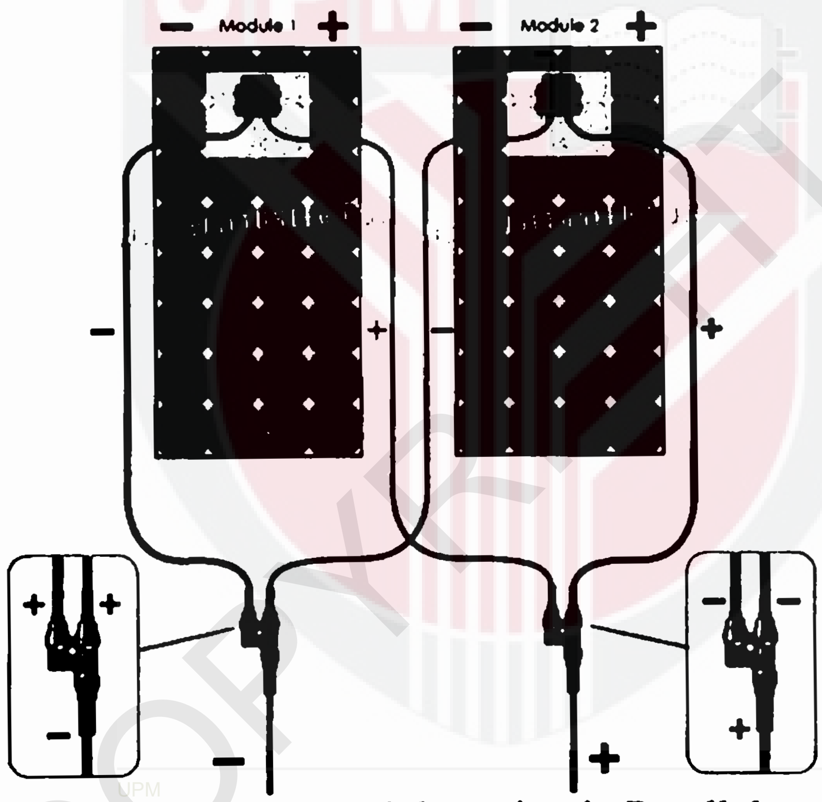


Figure 3.10: Solar module assign in Parallel mode

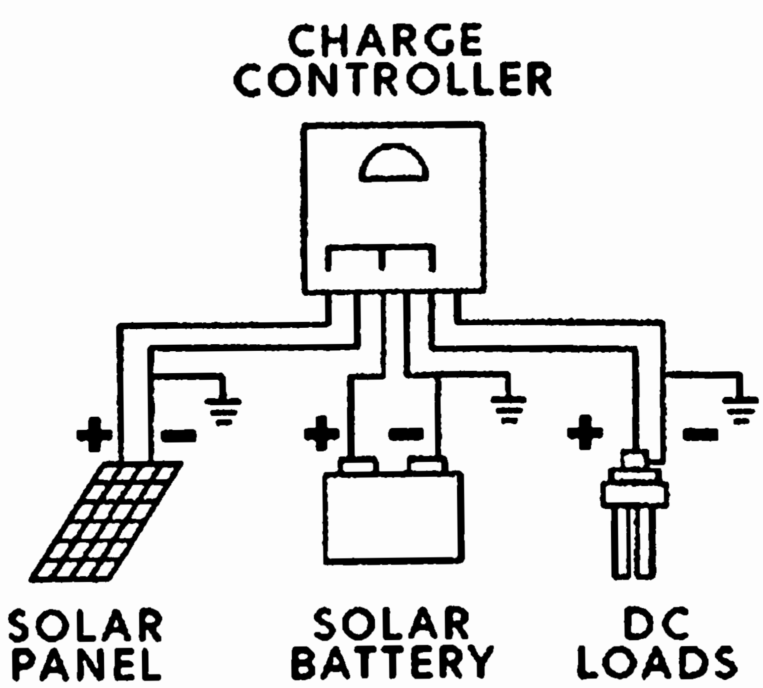


Figure 3.11: Solar PV wiring diagram

3.3.5 Level sensor installation

The level of water inside the growing tube is set at fix level to ensure the plant's roots can reach the water. Based on Figure 3.12, the minimum set point is 25.4 mm from below and that is where switch is mounted. If the water less that the set point, the switch will send electrical signal to turn the pump on. The volume of water in growing tube is estimated using formula of volume of cylinder

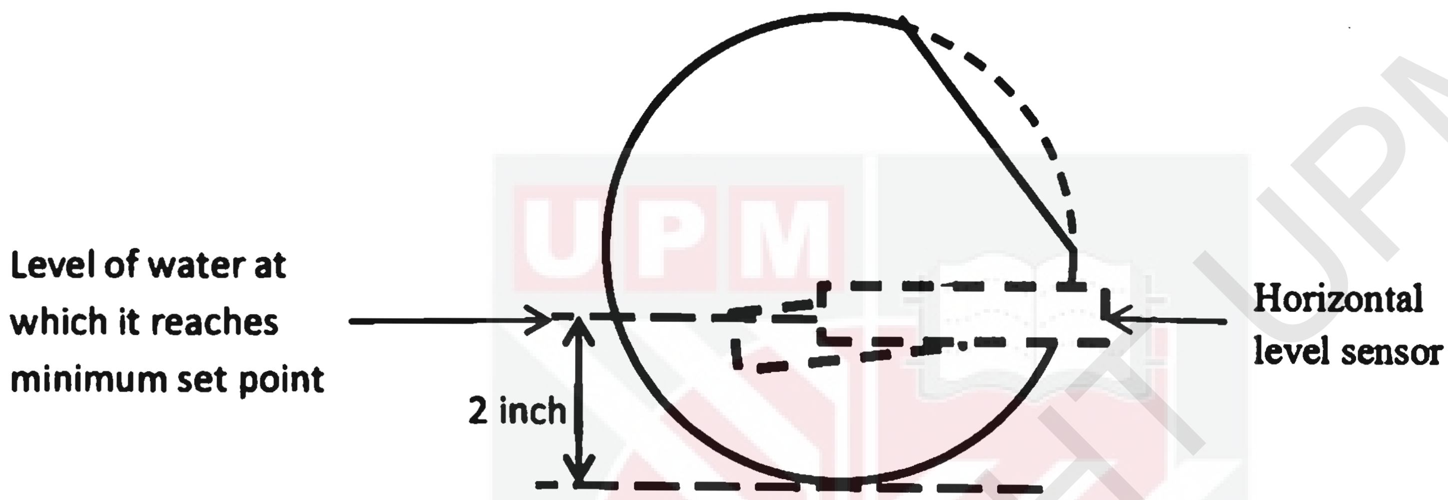


Figure 3.12: Cross-section of location of horizontal level sensor

The volume of water in growing tube is estimated using formula of volume of cylinder shown below

$$V = \pi r^2 h$$

$$Volume\ of\ water = (A_{Total\ sector} - A_{Water}) \times 2 \times h$$

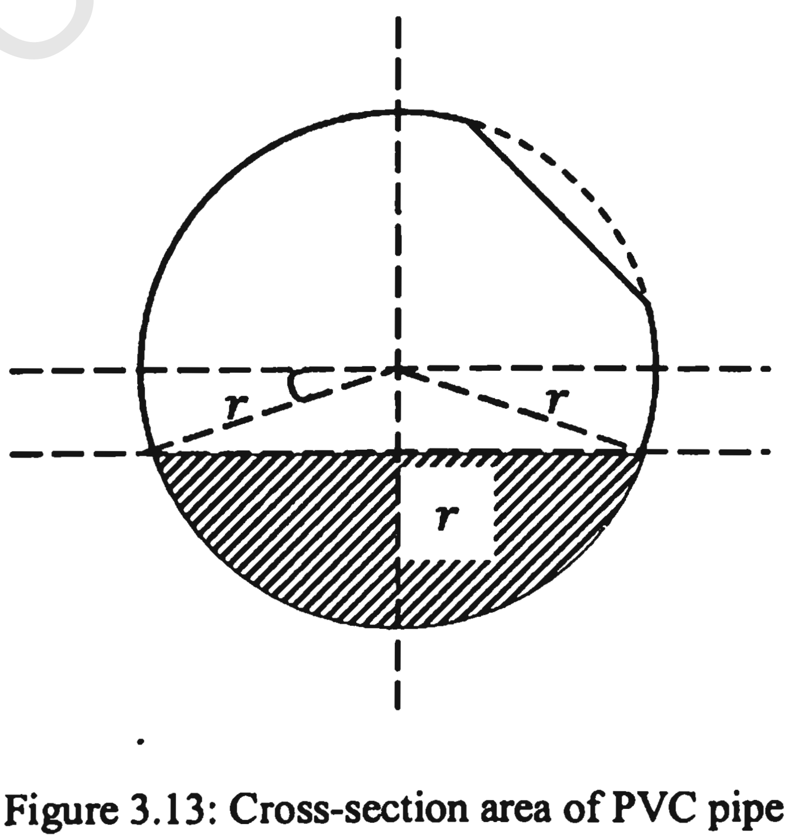


Figure 3.13: Cross-section area of PVC pipe

3.3.6 Pump and filter

There are many type of pump available in market where users can choose the most appropriate for the pump system. The requirement pump for this experiment is small in size yet has enough power to pump in water to growing bed. The pump selected is micro diaphragm pump which it moves the liquids through suction created by a vibration diaphragm. The benefit using diaphragm pump is affordable to operate in long term and more energy efficient with proper maintenance. The power need for the pump for every suction is 70 W. Other aspect need to be encounter is the liquid must clean and free of particle and gases. To overcome the problem, filter has to be attached at the inlet pipe of the pump to ensure small stone or the particles not get into the pump.

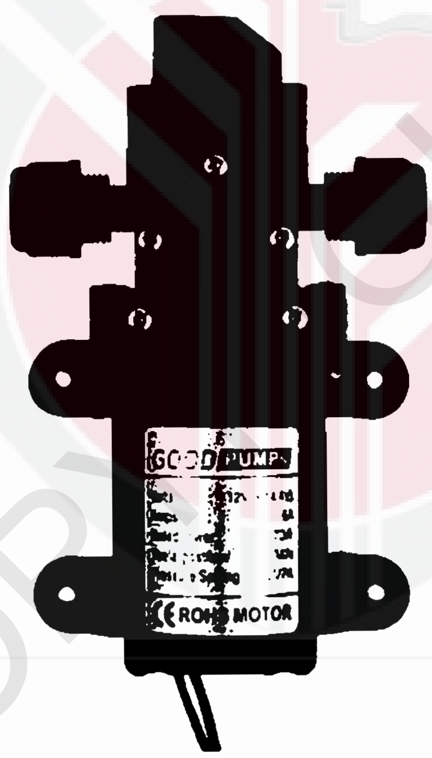


Figure 3.14: 70 W micro high pressure diaphragm pump

Since the available pump is selected, the net positive suction head available (NPSHA) is calculated to ensure it is equal or greater than the NPSHR. This calculation is important to avoid cavitation on the pump. The formula is shown below:

$$NPSHA = Atmopheric\ pressure\ (converted\ to\ head) + static\ head + surface\ pressure\ head - vapor\ pressure\ of\ product - loss\ in\ the\ piping, valve, fitting$$

$$NPSHA = p_g + p_z - p_{vp} - p_f$$

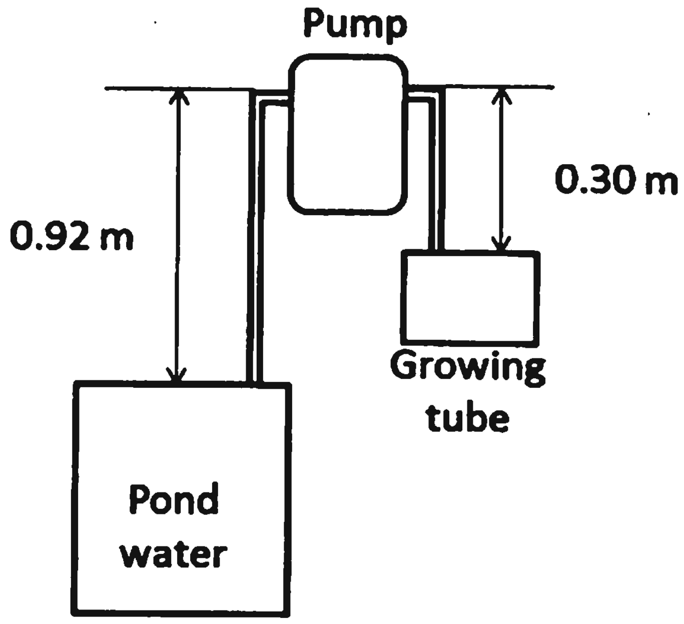


Figure 3.15: Diagram of pump

$Atmopheric\ pressure\ (converted\ to\ head) = 1\ atm = 10.4\ m$

$Static\ head = -0.62\ m$

$Surface\ pressure\ head = 0$

$Vapor\ pressure\ of\ product = 0.06546$ bar

$loss\ in\ the\ piping, valve, fitting = 0.0026\ m$

$$NPSHA = 10.4\ m - 0.62\ m - 0.0026\ m - 0.064\ m = \mathbf{9.71\ m}$$

Thus, the NPSHA is greater than NPSHR.

3.3.7 Data logger development

Data monitoring such as temperature, humidity, and flow rate is crucial to relate the environment effect with the growth performance. The data logger developed is using open source microcontroller an electronic components. The logger only measure three (3) fundamental weather data: temperature, humidity, pressure, and one (1) control data: flow rate. The system will run for 7 days to gather data and then are analyzed to correlate the environment with the project prototype and growth of plants. The main component needed for the data logger is microcontroller board (Arduino Mega 2560), sensor shield (Arduino Ethernet Shield), SD card (San Disk 32 GB extreme). Auxiliary component such as wire, cable gland, heat sink, silencer and others also included.

Table 3.4: Market price for main component

Component	Model	Price
Microcontrolller board	Arduino Mega 2560	RM 45.00
Sensor shield	Arduino Ethernet shield	RM 30.00
SD card module	San Disk 32 GB extreme	RM 45.00

3.4 Seedling Preparation

Pak Choi plant is selected for this experiment where the germination period is 2 weeks and after that the plant can be transplant into growing type. Medium used to germinate is horti-cube (Figure 3.16) which it easily degradable and it is made from plant.

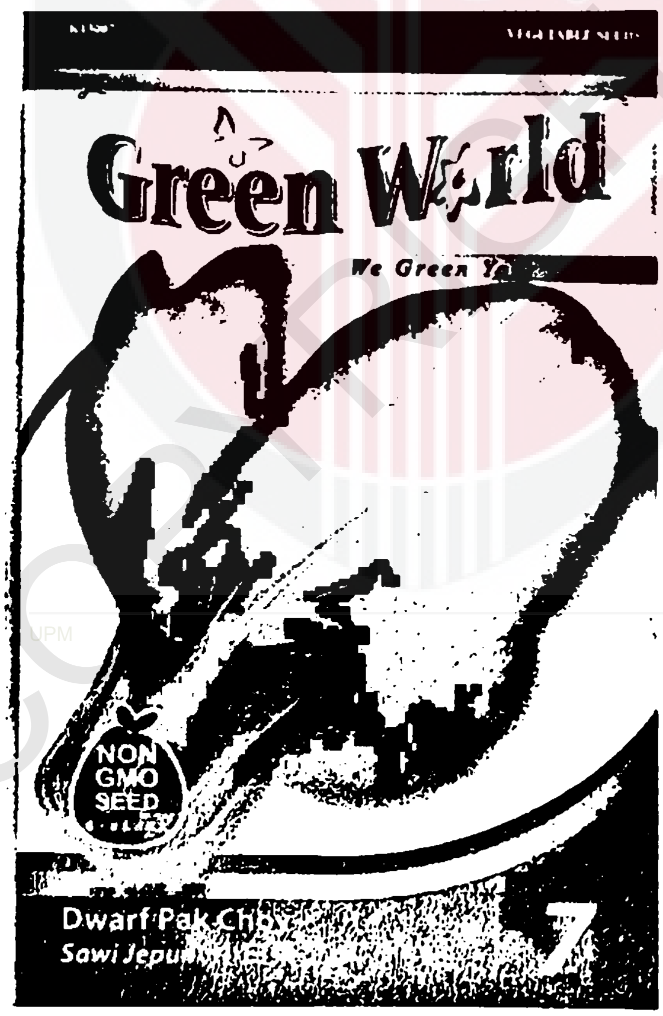


Figure 3.16: Dwarf pak choy seeds

Figure 3.17: Horti-cubes

3.5 Conduct experiment and field observation of plant growth

At this stage, the experiment and observation is takes place, the Floatoponic is attach and tighten with pontoon to float it on the pond. The hydroponic system apply is deep water technique (DFT) which using feedback control system where water only pump into the growing tube water level when below set point. The fertilizer (A and B mix stock) is feed into the growing tube manually and monitor once in 3 days and added if necessary. The EC value for Pak Choy plant is around 1.0-1.5 which below then this value the plant will deteriorate.

CHAPTER IV

RESULTS, ANALYSIS AND DISCUSSION

4.0 Introduction

In this chapter, all the research and planning on Floatoponic is executed and prototype is construct as well as data is collected for the result to be recognized and documented. Besides, objective can be accomplished by providing project scope and goals. After completely analyse the result in this chapter, the next Chapter V: *Discussion, Conclusion and Recommendation* will provide further details on problem and ways to improve the system.

4.1 Construction of Floatoponic

The construction of Floatoponic prototype will be guided based on the planning done in Chapter 3 in design section to ensure proper connection and structure. The finished structure of Floatoponic may differ from the designed structure as direct modification is made to increase the stability of Floatoponic structure.

4.1.1 Frame

In order to reduce cost, the slotted angle iron from Floating PV Dryer is dissembled and painted with anti-rust paint to deplete the potential of rusting due to the unpredictable environment. Then, it was assembled into rectangular frame as shown in Figure 4.1. Table 4.1 shows the number of slotted angle iron used per length that has been set.

Table 4.1: Number of slotted angle iron used per length

Length of Slotted angle iron	Number of Slotted angle iron used
2.13 m	10
1.23 m	7
0.89 m	2
0.18 m	1

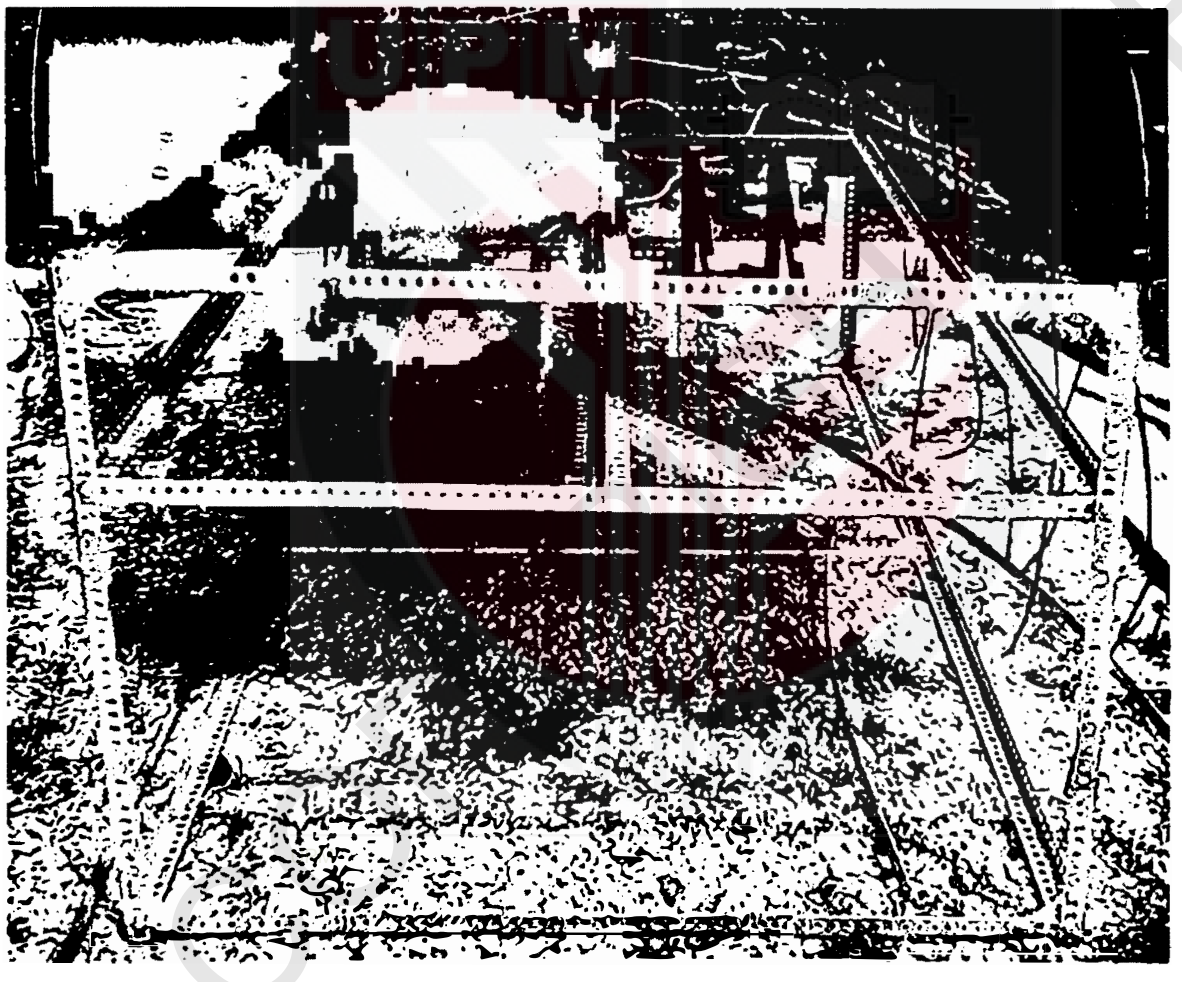


Figure 4.1: Assembled frame

4.1.2 Solar Panel Support

There are 3 Aluminium plate is with dimension of (2 pieces x 2 m x 0.610 m x 0.001m) (1 piece x 2 m x 0.914 m x 0.001 m) used and bent into arc shape of 180 degree angle (Figure 3.4) and angle height is 30 inch to support the flexible solar panel as shown in Figure 4.2. Eight (8) - solar panel is mounted at top of the aluminium sheet with M8 stainless steel hex bold and nut. The purpose of cutting the aluminium plate into 2 different dimensions is to ease the installation with securely handling.

Figure 4.2: The Solar PV is supported with aluminium

4.1.3 Hydroponic Growing tube

The growing tube is drilled in circular shape of diameter 0.05 m in order to place the planting pot. The process of preparing the growing tube is explained in following steps;

Step 1:

A straight line of 0.03 m from the middle on the PVC pipe which equivalent to 45° angle.

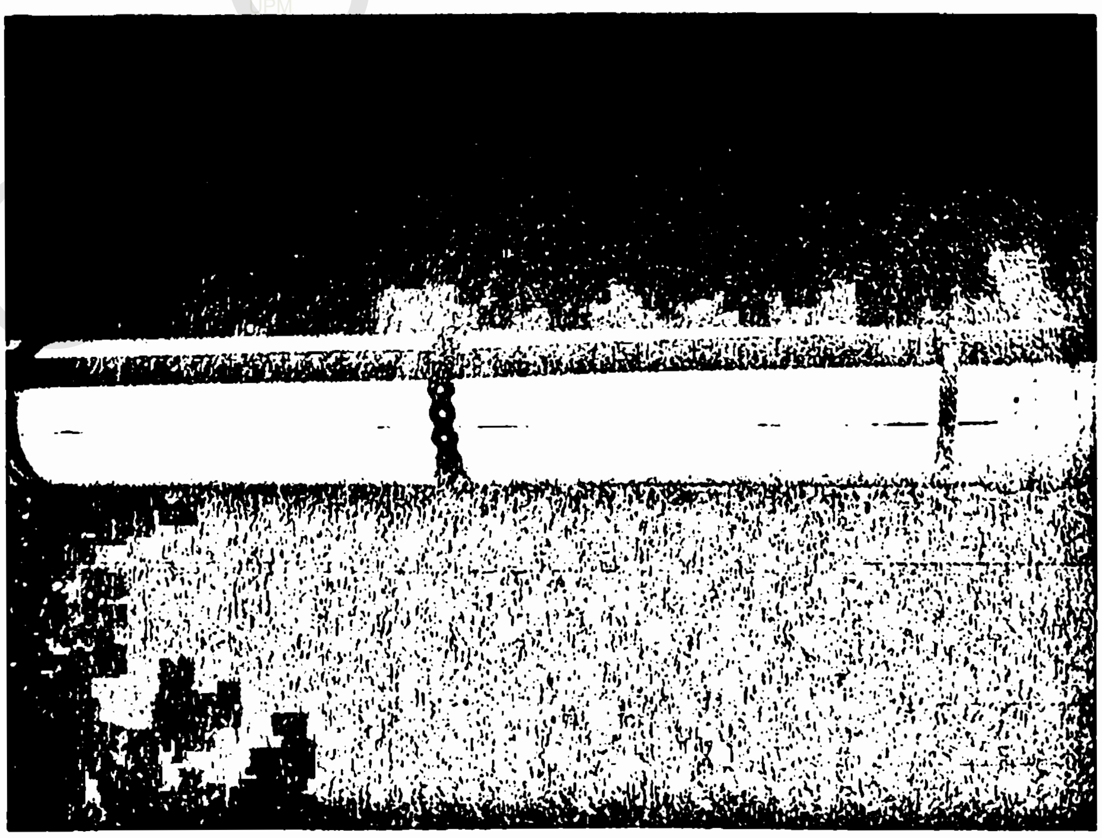


Figure 4.3: Straight line is traced on PVC pipe

Step 2:

0.04 m distance from point to point is mark. The marked point is indicating the middle of the hole.

Figure 4.4: Marked point with 0.04 m distance

Step 3:

The marked point is drilled using driller with 50 mm metal plate twist drill bit.

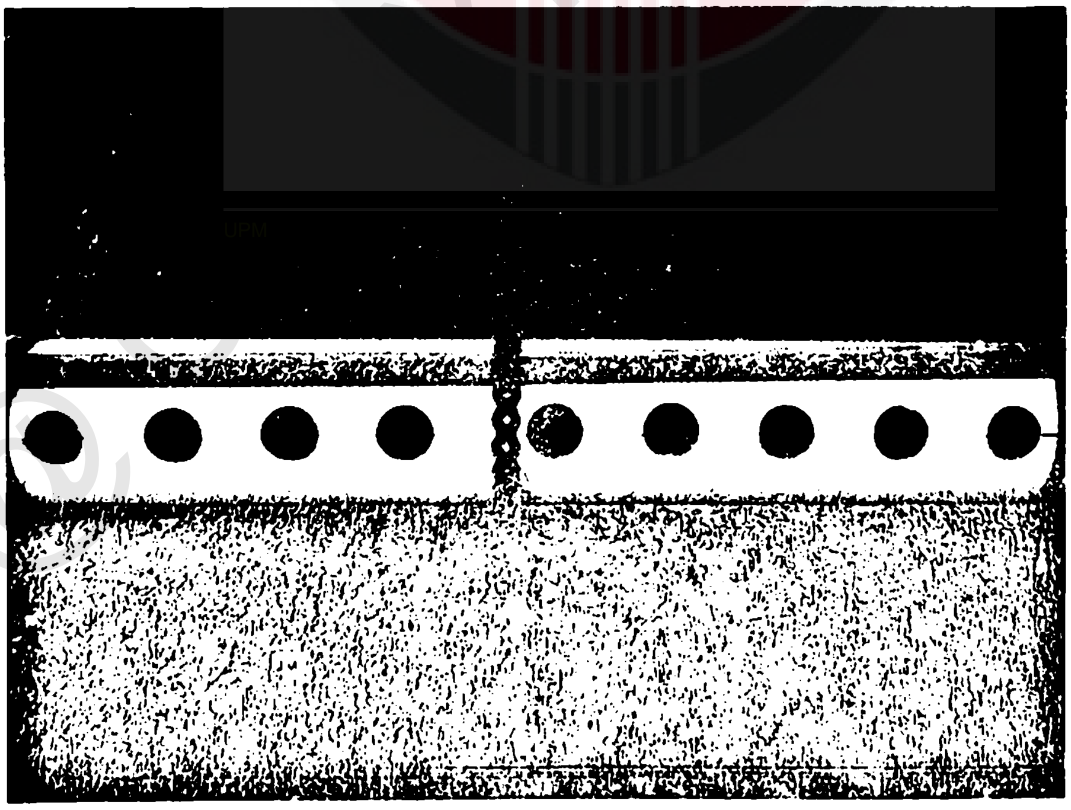


Figure 4.5: Drilled holes with diameter of 0.05 m

4.1.4 Wiring

In order to complete the wiring there are steps that had been executed so that the process flow is well ordered.

Step 1: Additional of battery compartment

To place the battery additional of slotted angle is needed to place and support the battery. The battery will be place vertically (Figure 4.6). The dimension of the battery is taken which the length is 0.41 m and the width is 0.18 m. Then, the slotted angle iron is measured where 1 piece of 1.23 m long with additional 0.04 m tolerance and 2 piece of 0.41 m long with additional 0.03 m tolerance is cut. The slotted angle iron is mounted and battery is place on the compartment.

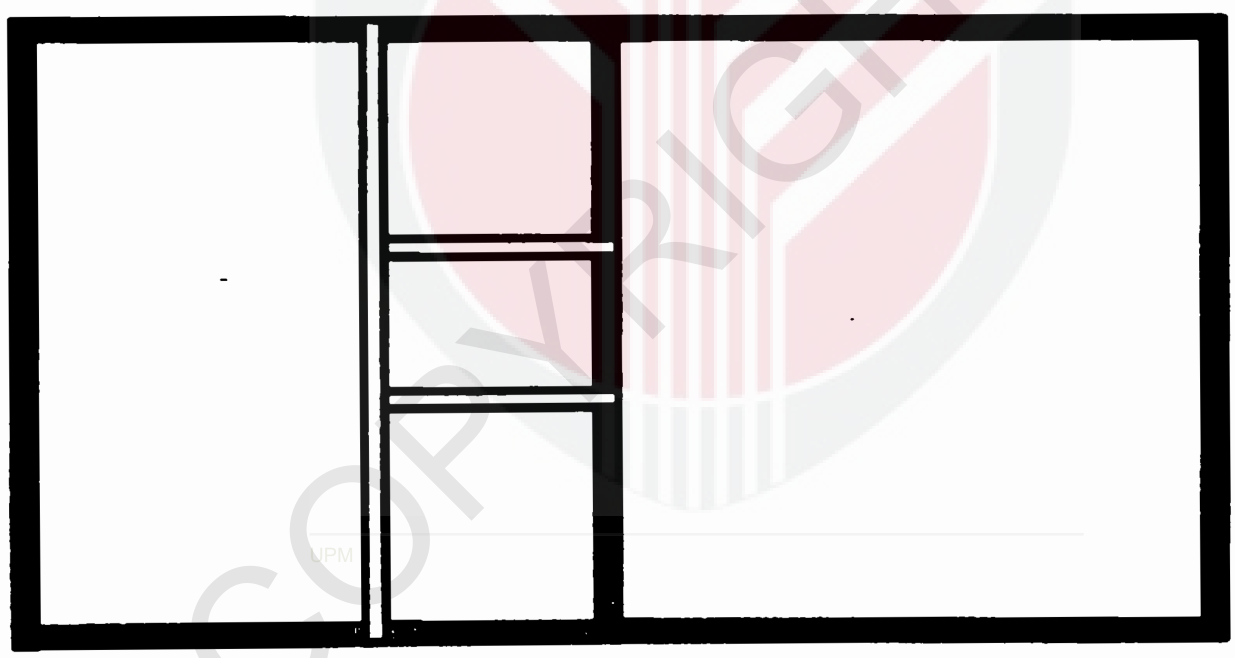


Figure 4.6: Top view of additional compartment for battery

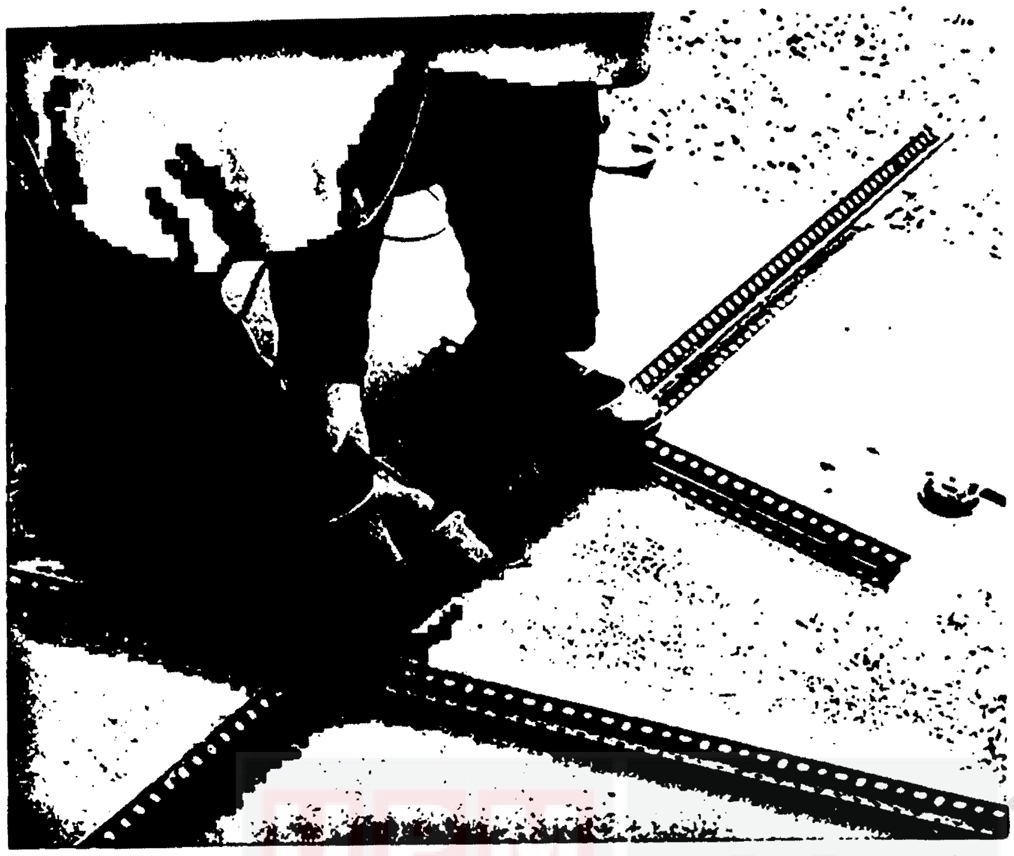


Figure 4.7: Cutting process of slotted angle iron

Figure 4.8: Additional compartment for battery placement

Step 2: Mounting electrical meter box

At first, an aluminium plate with dimension of 1.23 m x 0.3 m is mounted on the aluminium plate. Then, Electric meter box is mounted at the middle top of Floatoponic and the solar charger controller, electrical circuit breaker and connector are attach inside it as shown in figure 4.9. All the wire is connected in this electrical meter box.

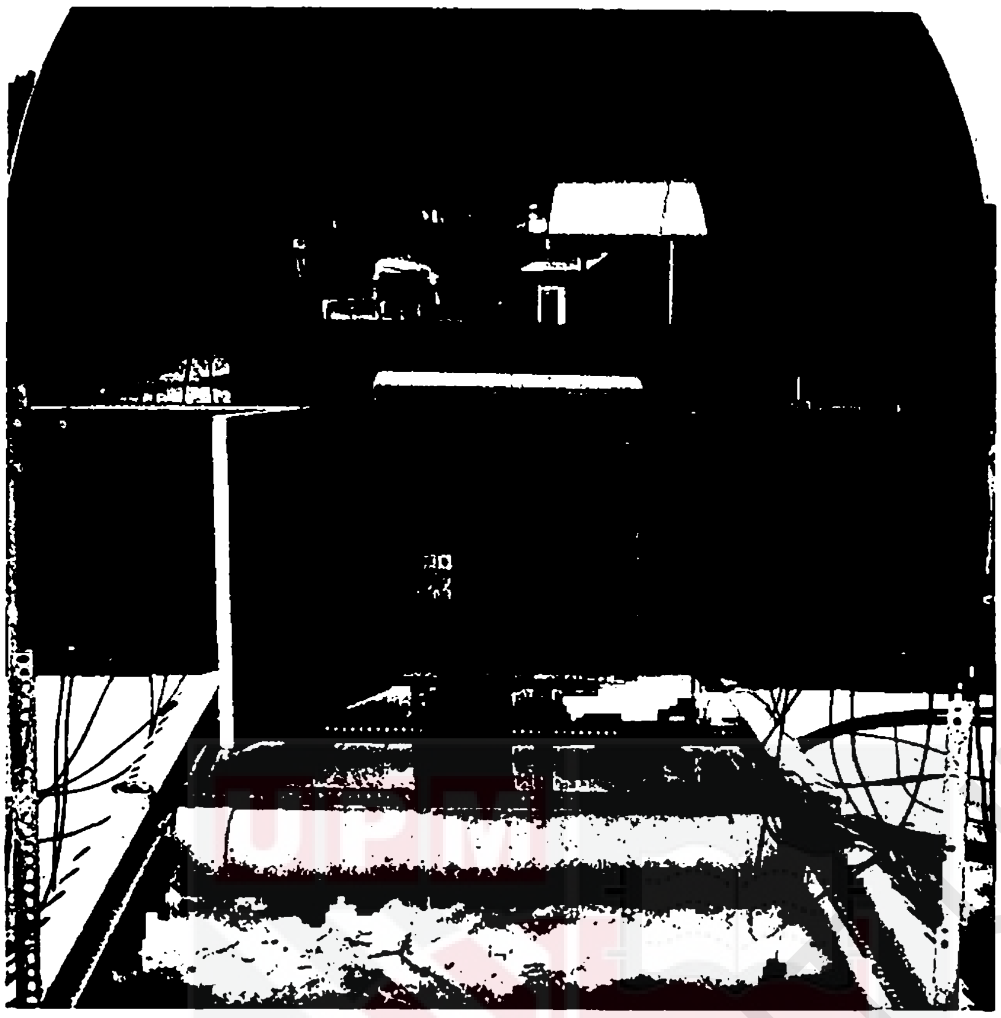


Figure 4.9: Electrical meter box mounted on Floatoponic

Step 3: Positive and negative connection of Solar panel.

The negative and positive terminal is tested using multimeter and marked with black tape (negative terminal) and red tape (positive terminal). Cover is mounted at below the solar panel to protect the wire from environment exposure that can cause damage.

Figure 4.10: Polar checking to differentiate between positive and negative terminals

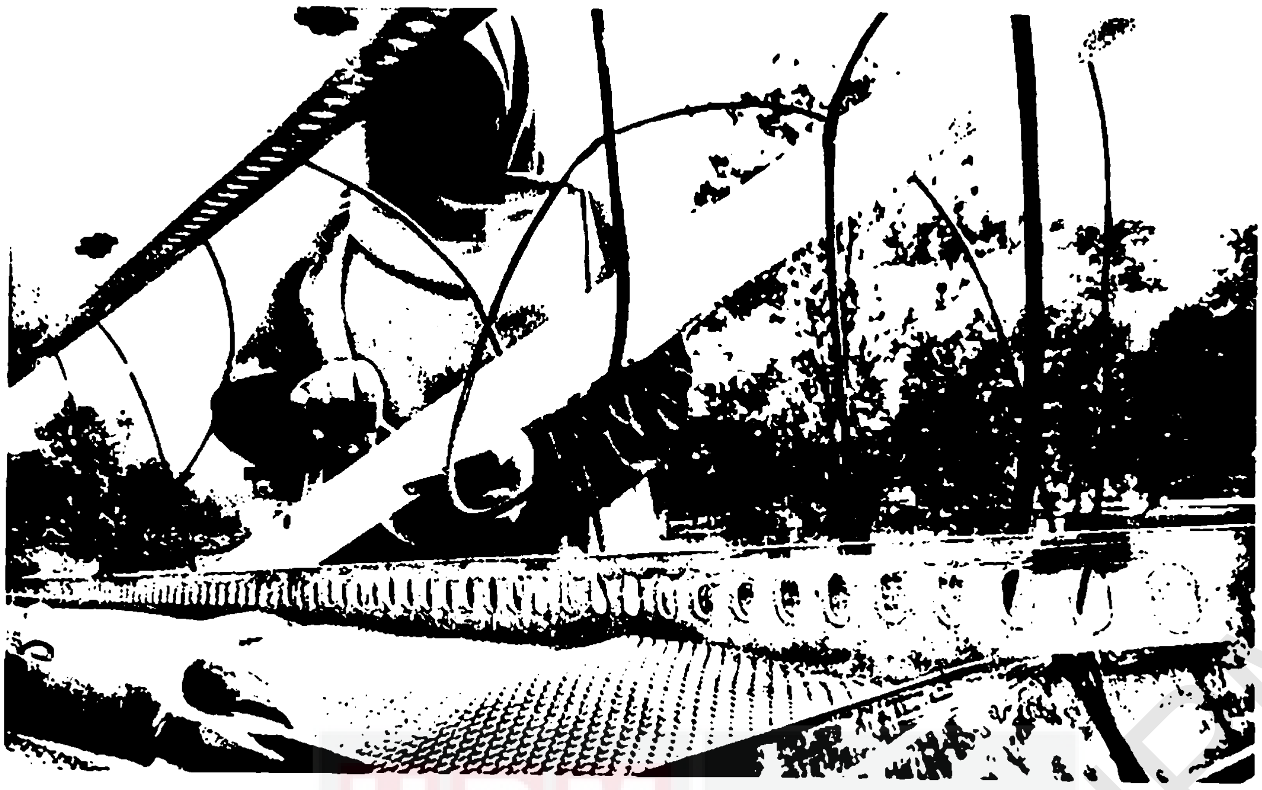


Figure 4.11: Placing wire inside the cover

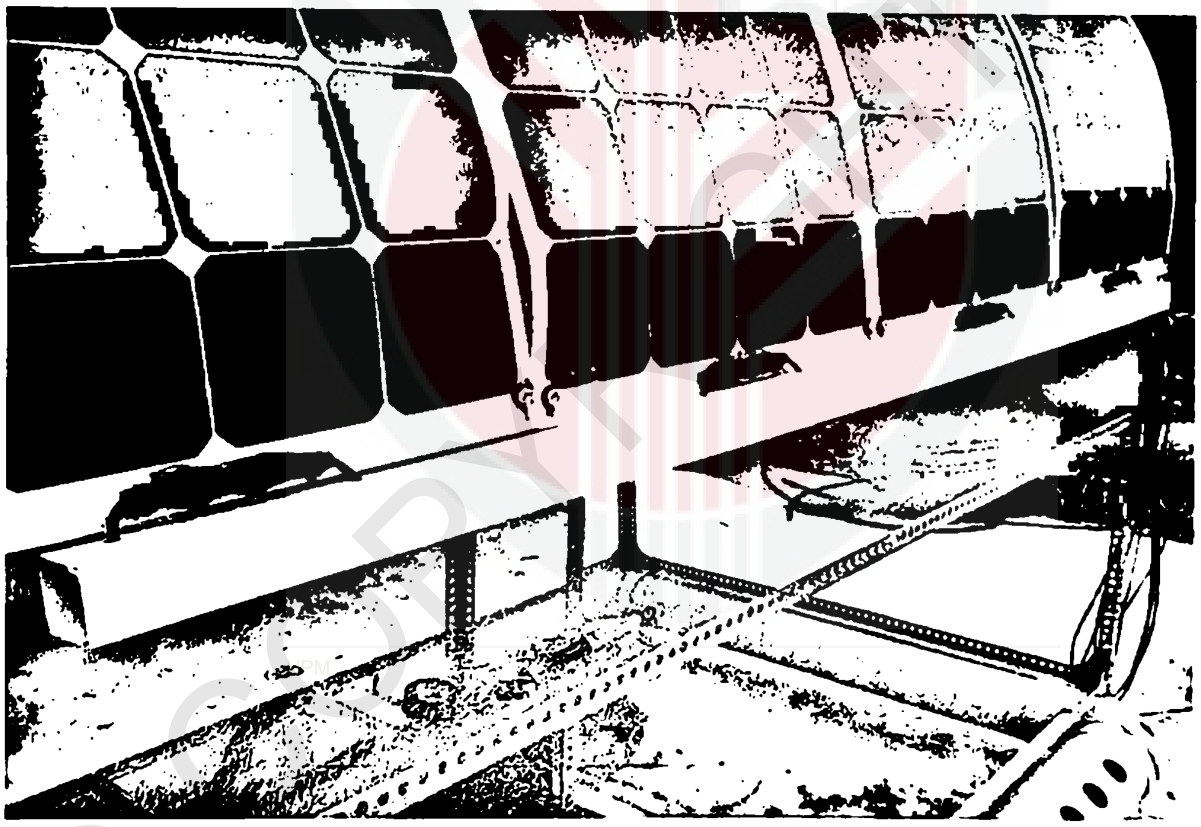


Figure 4.12: Cover for the solar panel wire

The negative and positive terminals marked before is inserted inside the split loom tubing to resist it from water. Then, it is connected to two (2) junction block with respect to positive and negative terminal.

Figure 4.13: Connecting wire to junction block

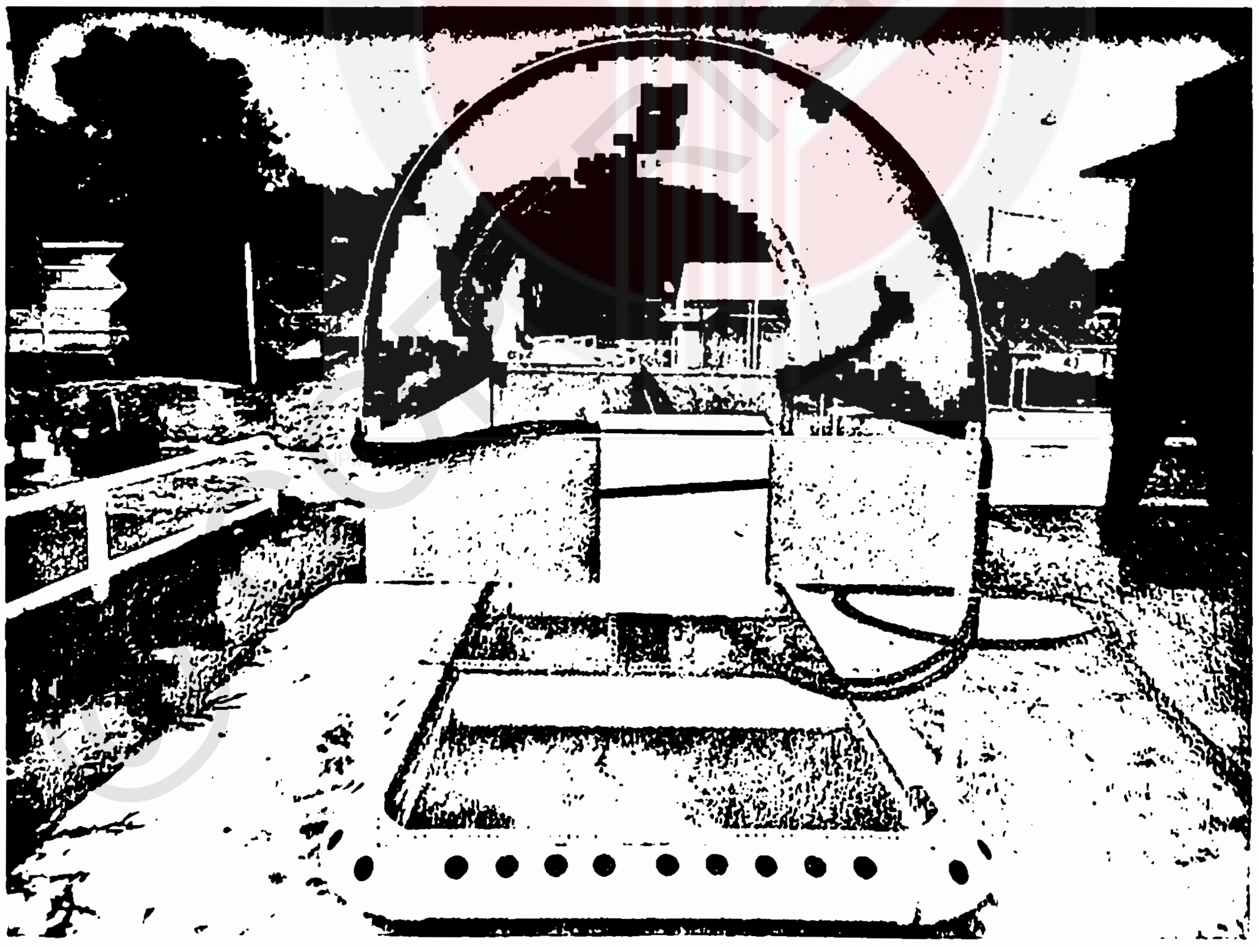


Figure 4.14: Positive and negative terminals are connected to the junction block inside the electric meter box

4.1.5: Level sensor installation

The minimum set point level is 0.0254 m depth and that is where level switch is mounted. If the water less that the set point, the switch will send electrical signal to turn the pump which the circuit is in closed circuit.

Figure 4.15: Soldering the auxiliary wire with the sensor

The volume of water in growing tube is estimated using formula of volume of cylinder shown below:

$$V = \pi r^2 h$$

$$Volume\ of\ water = (A_{Total\ sector} - A_{Water}) \times 2 \times h$$

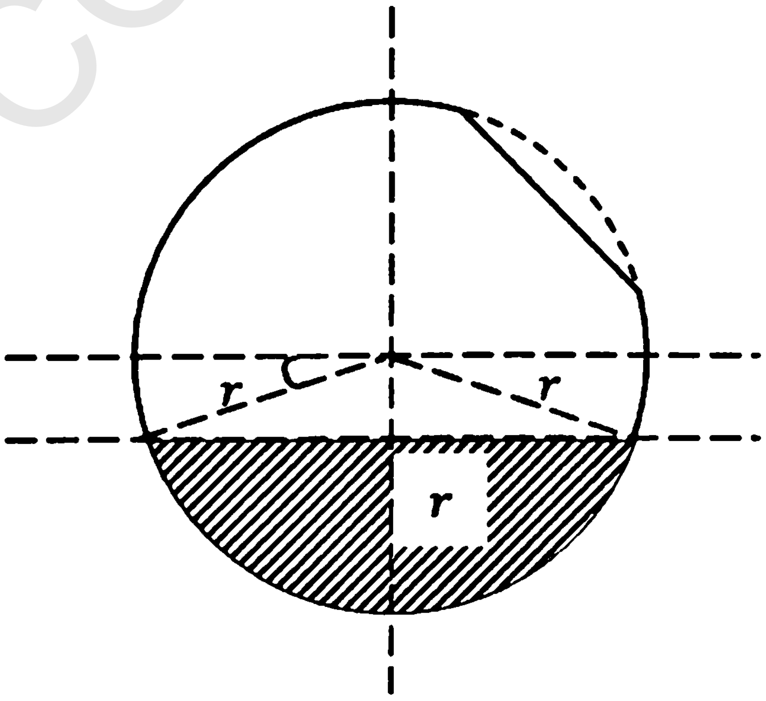
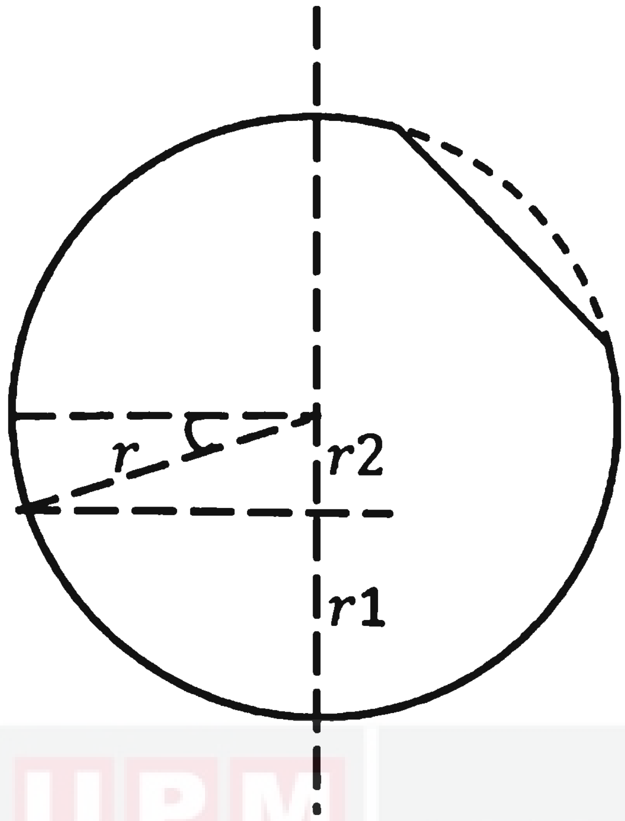


Figure 4.16: Cross-section area of PVC pipe



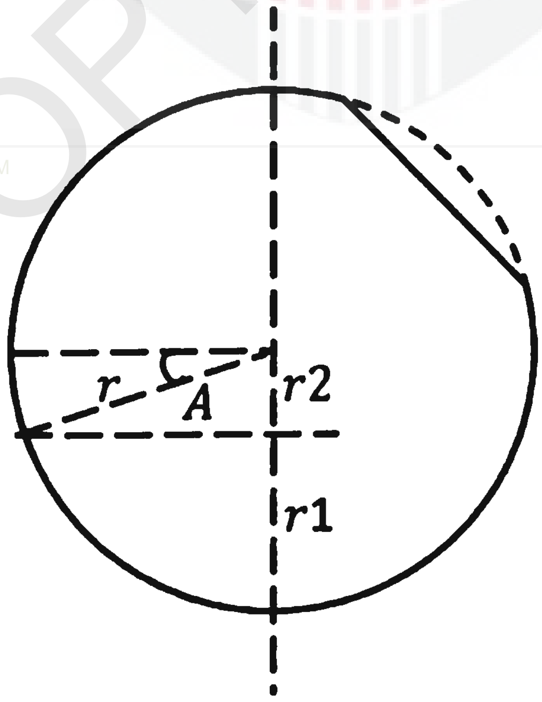
Define r;
$r = 0.08\,m \quad r1 = 0.0508\,m \quad r2 = 0,0292\,m$

Find the angle;

$$\theta = cos^{-1}\frac{0.029\,m}{0.08\,m} = 68.75°$$

$$r3 = \sqrt{0.08^2 + 0.0292^2} = 0.07448\,m$$

Area of A;



$$A = \frac{1}{2} \times 0.07448 \times 0.0292 = 0.001089\,m^2$$

Area Full sector;

$V = \pi r^2 h$

$$V = \frac{68.75°}{360°} \times 2\pi \times \frac{0.08^2}{2} \quad = \quad 0.003840\, m^2$$

Volume of water;

$$Volume\ of\ water = (A_{Total\ sector} - A_{Water}) \times 2 \times h$$

$$= (0.003840\, m^2 - 0.001087\, m^2) \times 2 \times 7.8\, m$$

$\underline{Volume\ of\ water = 0.335\, m^3}$

4.1.6 Pump installation

70 Watt Micro high pressure diaphragm water pump is secured inside the electrical junction box to avoid water from get into the pump and to ease the process of mounting at the side of galvanized steel slotted angle. The side of the junction box is drilled and cable gland is fixed to hold the inlet and outlet pipe.

Figure 4.17 Pump is mounted at the side of galvanized steel slotted angle

4.1.7 Water filter

1 m of 80 mm PVC pipe is cut and drilled to make random holes (0.4 m long) such that water can fill inside it. 0.4 m long of aquarium filter sponge is cut and place around the holes and tied with cable tie. The filter is closed using 2 pieces of 80 mm end cap for top and bottom respectively. The top end cap is drilled and connects with cable gland where the pipe will inserted into the filter through the cable gland and tighten.

Figure 4.18: Drilled pipe

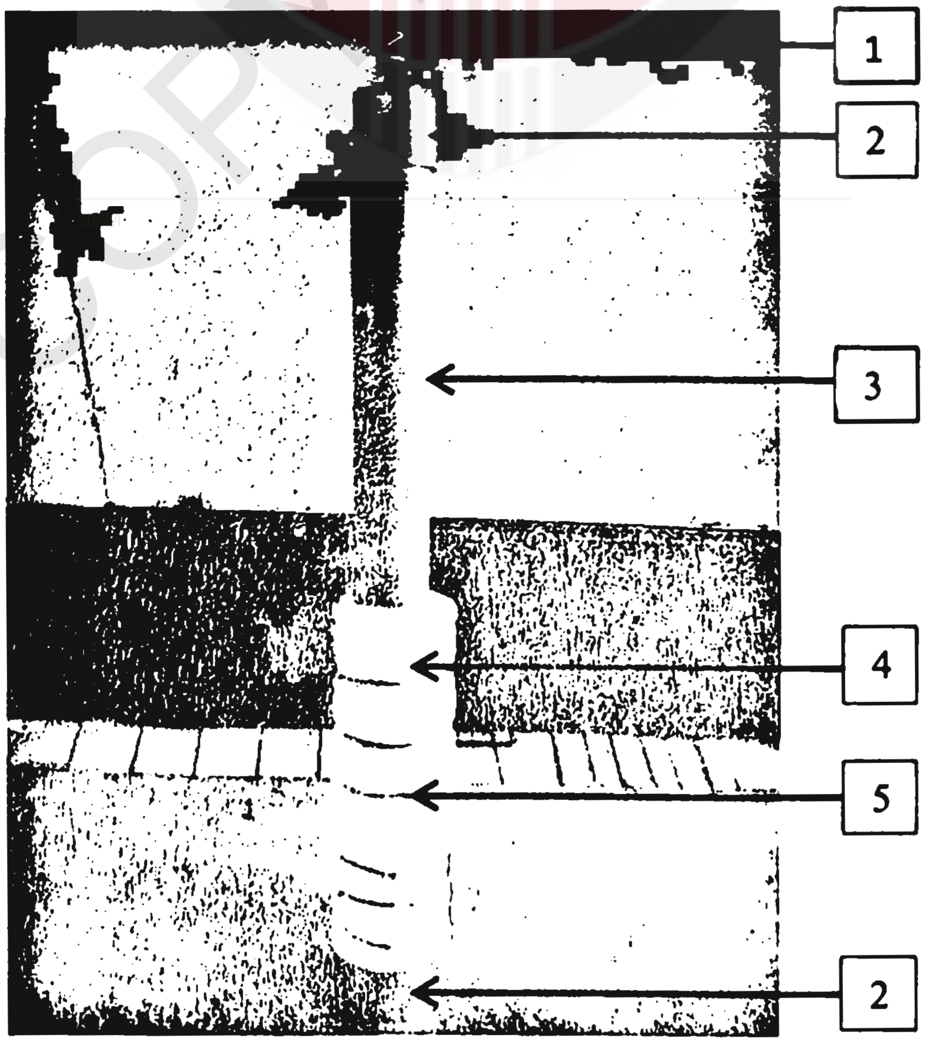


Figure 4.19: Prototype of water filter

Material used to build the filter is shown in Table 4.2;**Table**

Table 4.2: Material used for water filter

No.	Material
1	Cable gland (PG 16)
2	2 x 80 mm PVC fitting end cap
3	80 mm PVC pipe
4	Aquarium Filter sponge
5	Cable tie

4.1.8 Balancing trial

After all the important component is constructed successfully, the Floatoponic is placed on pontoons that arrange 3 by 4 pieces. The Floatoponic is tight using steel bend for make sure the Floatoponic not slip or get off from the pontoons. Figure 4.20 shows that the Floatoponic is not balance with 12 pontoons as the surface area of the combination of pontoon is smaller than the area of Floatoponic.

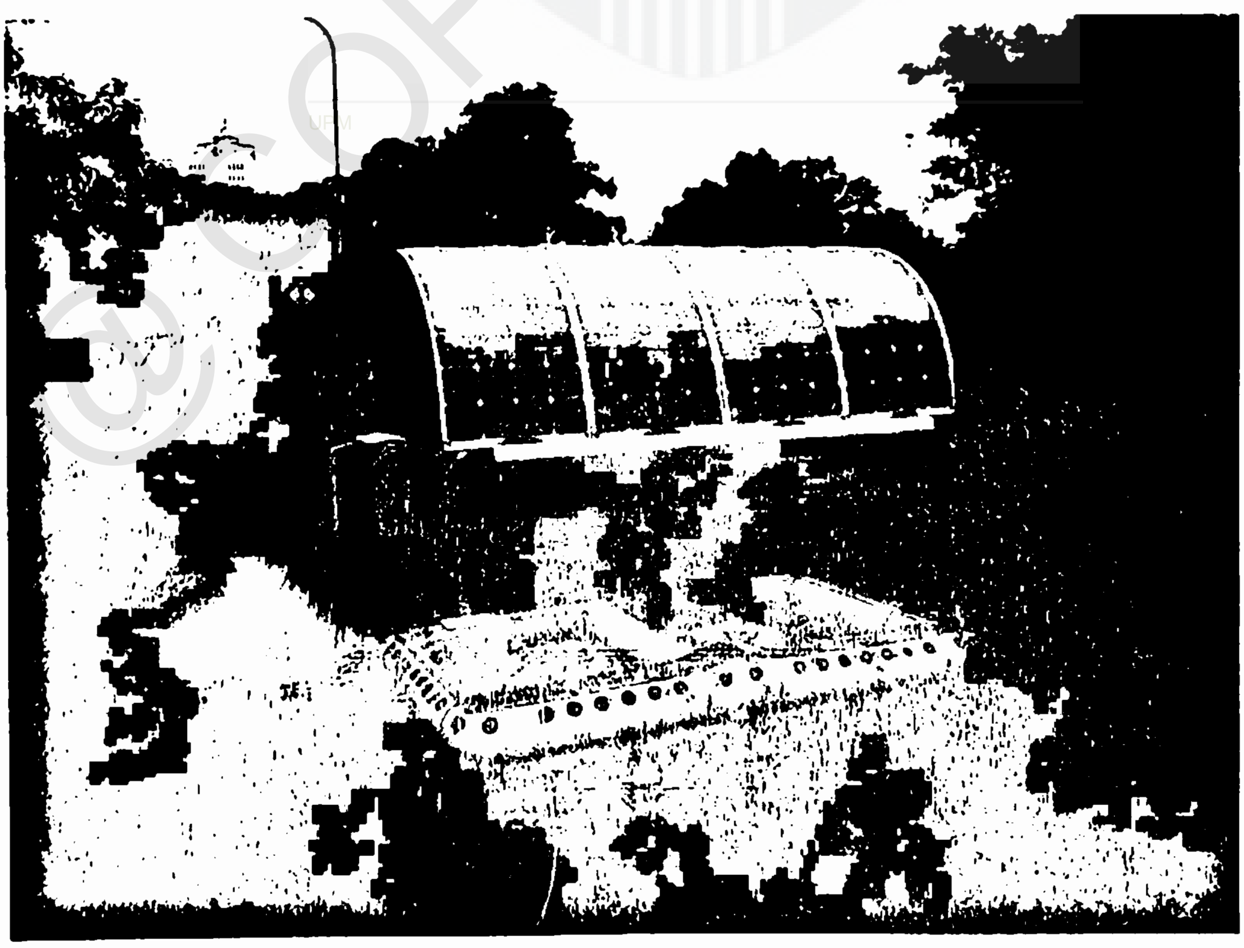


Figure 4.20: First trial of releasing Floatoponic into pond

To overcome the problem, another 8 pontoons is added where the arrangement to 5 by 4 pieces and total become 20 pontoons. The additional of pontoons enlarge the surface area to support and stabilize the Floatoponic.

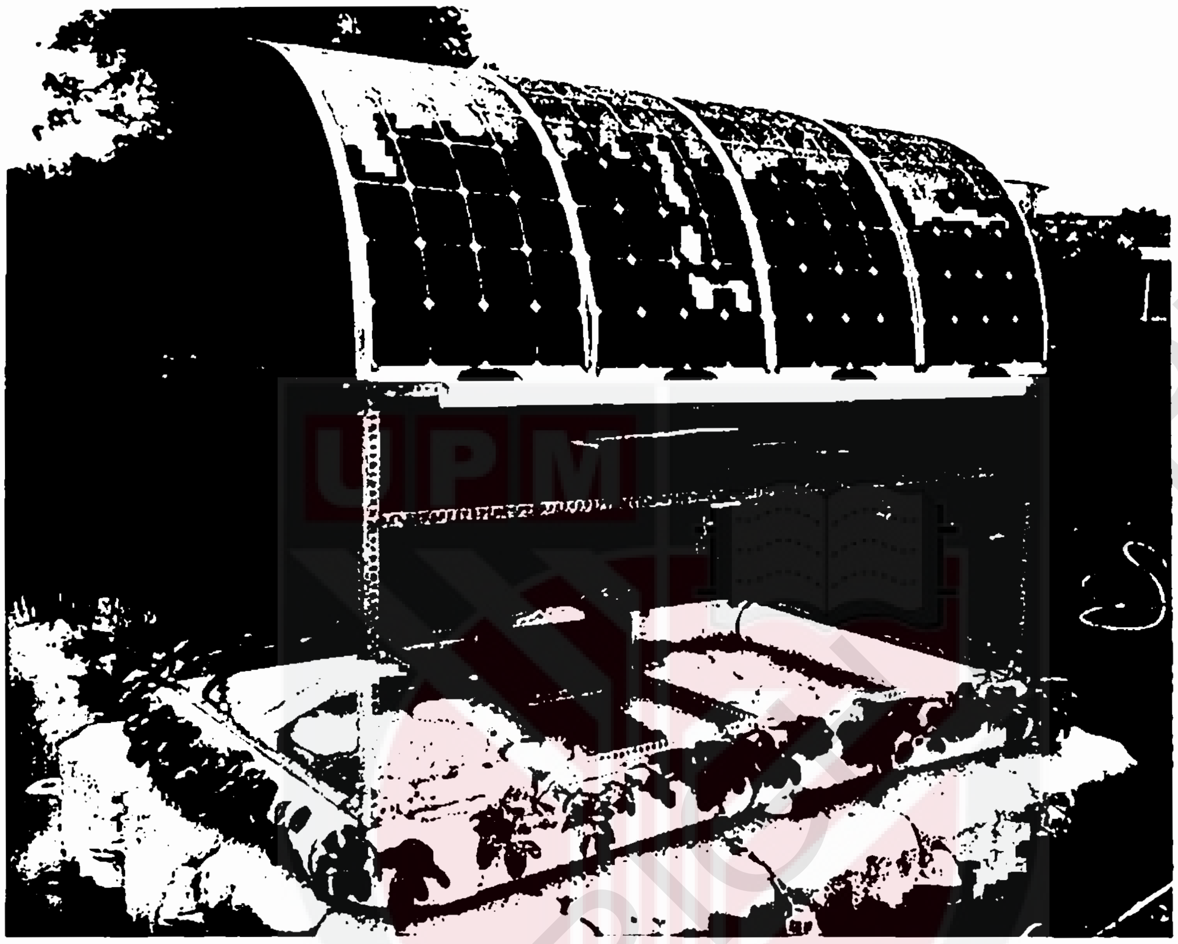


Figure 4.21: The Floatoponic is more stable after adding extra float

4.2 Seedling preparation

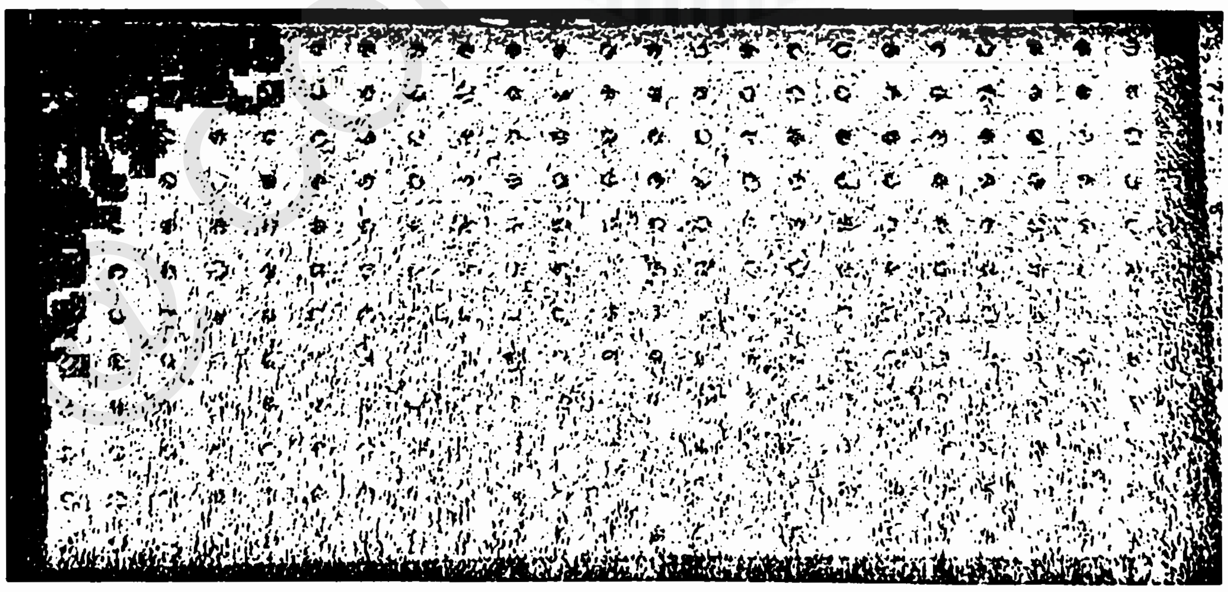


Figure 4.22: 1 week germinated seeds

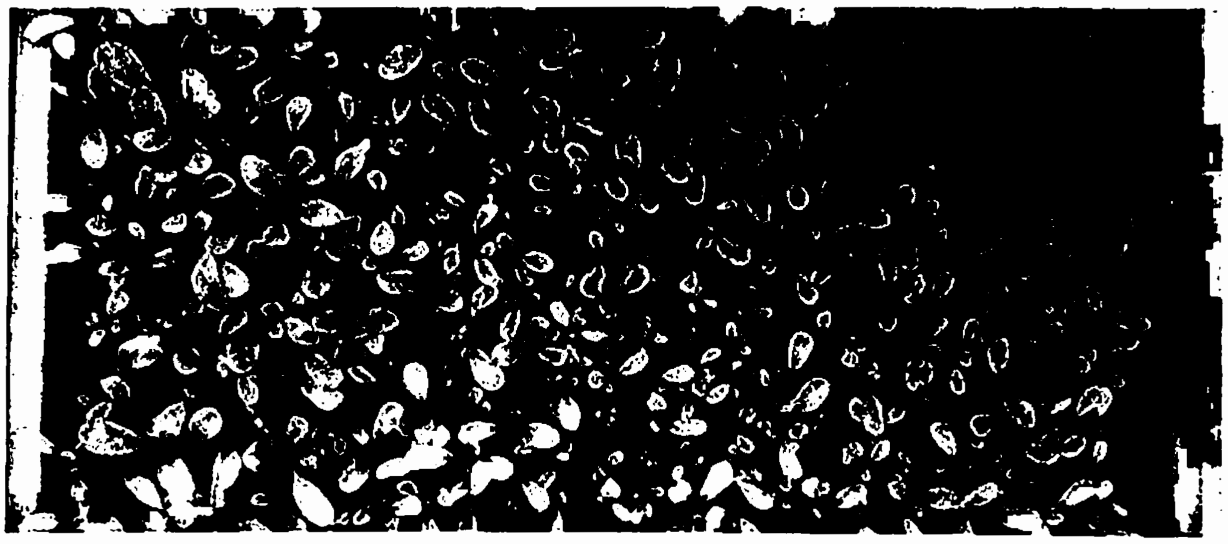


Figure 4.23: 2 weeks germinated seeds

Transplanting

After 3 weeks the crops is transferred inside the pot with additional of coco-fiber as growing media. The fertilizer used is AB mix fertilizer and EC value is maintain at 1.0 -1.5 with regular monitoring to maintain the EC value. The fertilizer is filled manually when needed. The crops then need 4 days to adapt with new environment.

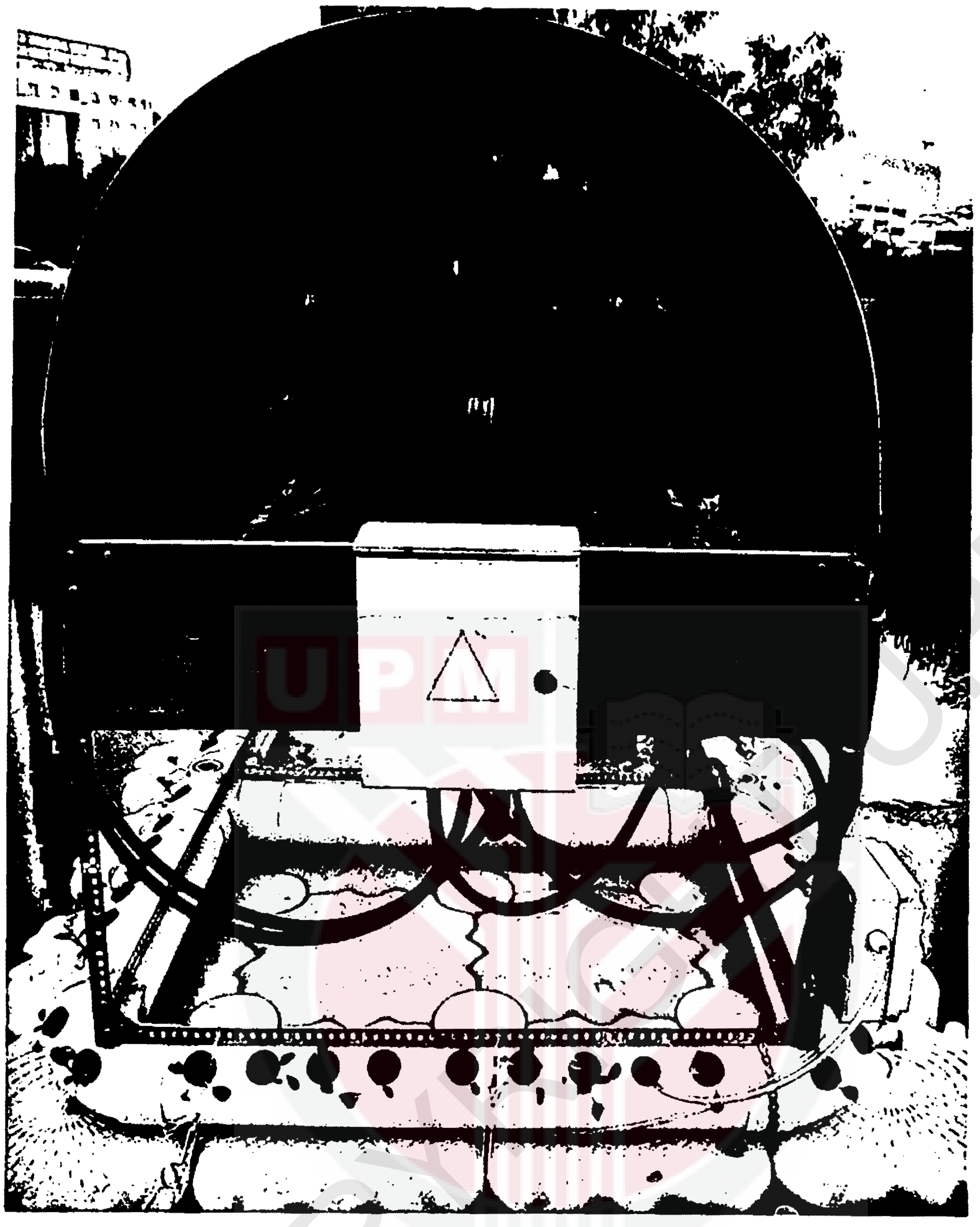


Figure 4.24: The crops is transplanted after 3 weeks into growing tube

4.1.9 Comparison of design and real prototype

Based on the design drawing proposed, the prototype are 90% successfully followed which mean the level of devotion to the design drawing specification decides the quality of project and influence the performance of the constructed work.

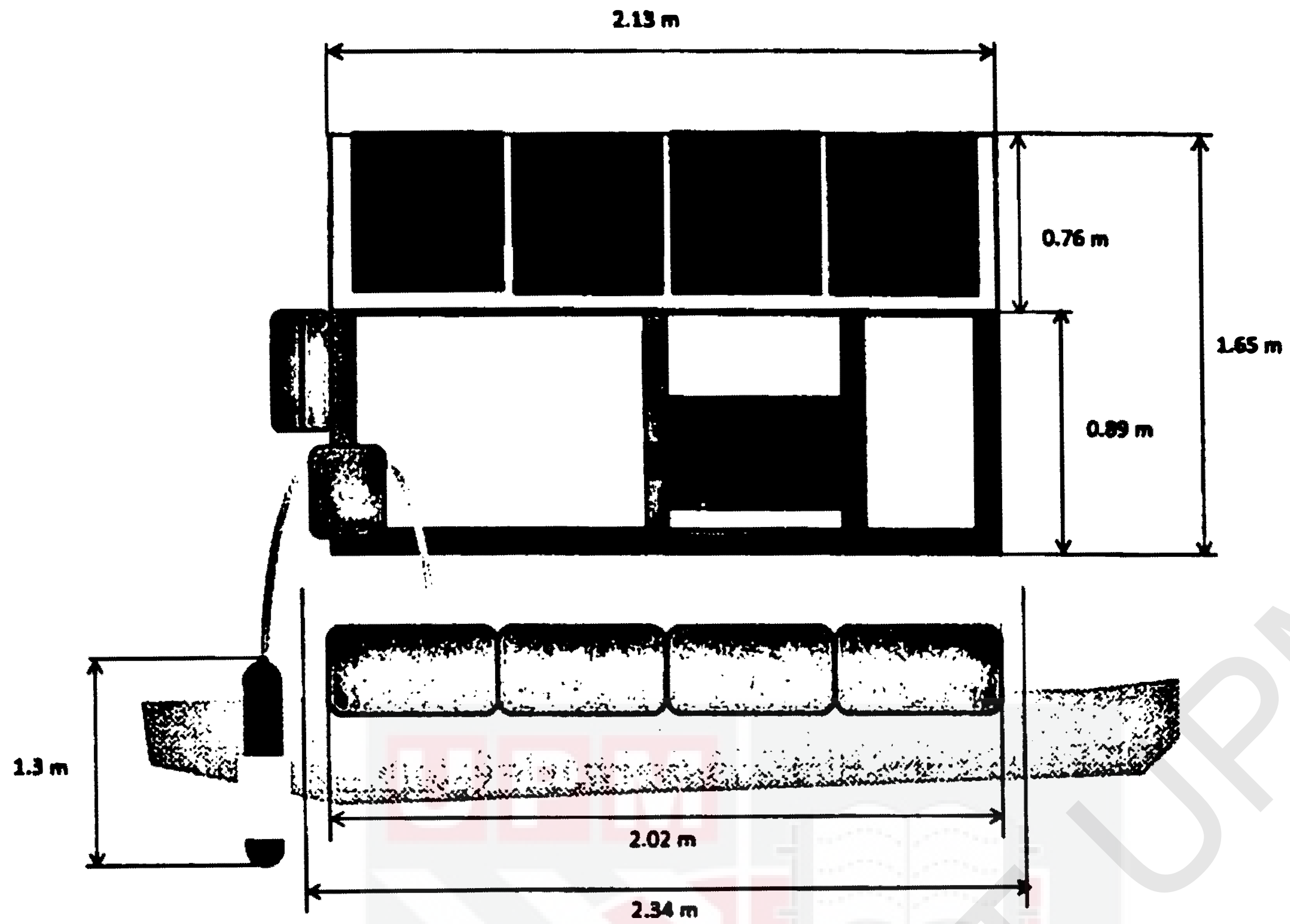


Figure 4.25: Design prototype

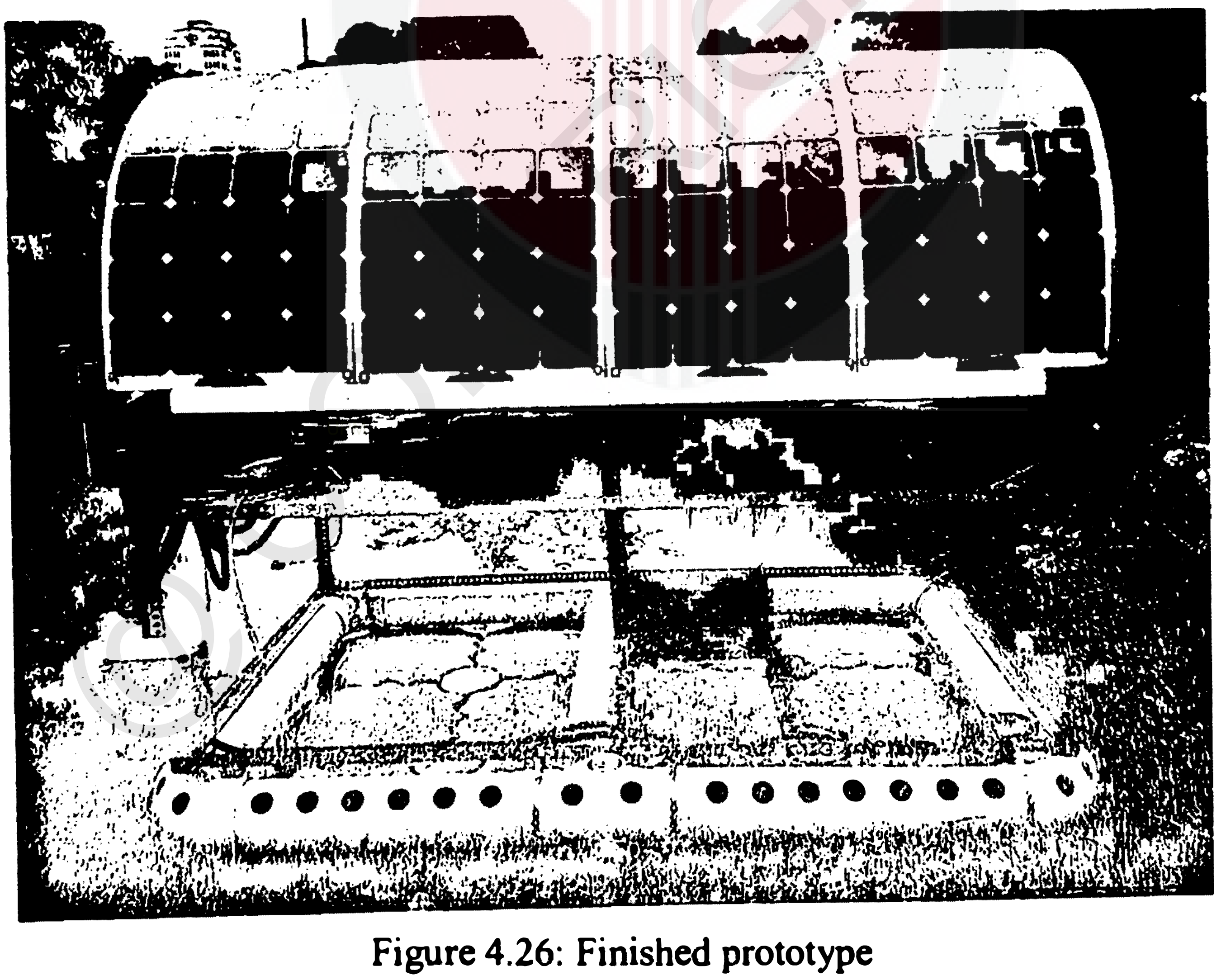


Figure 4.26: Finished prototype

4.1.10 Data logger development

There are eight (8) elements of temperature sensor, two (2) elements of humidity element, and one (1) element of flow-rate of water. The logger is programmed by using Arduino IDE platform which giving ability to collect data.

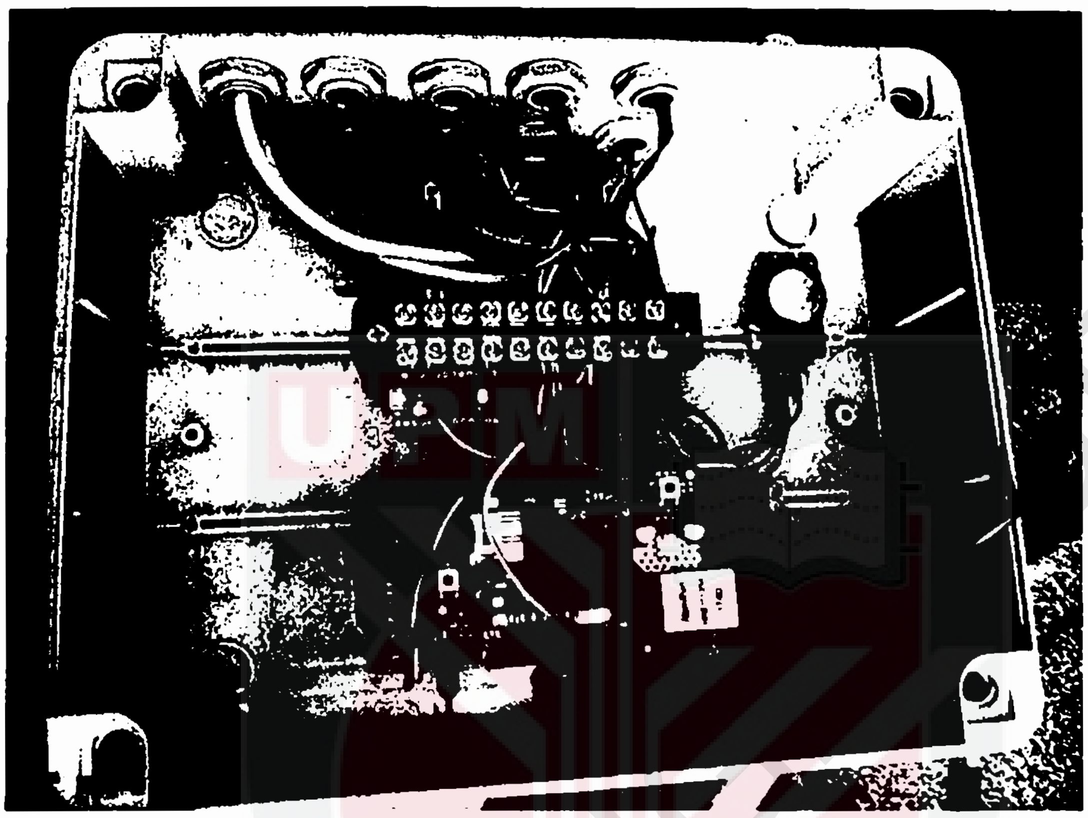


Figure 4.27: Data logger connection

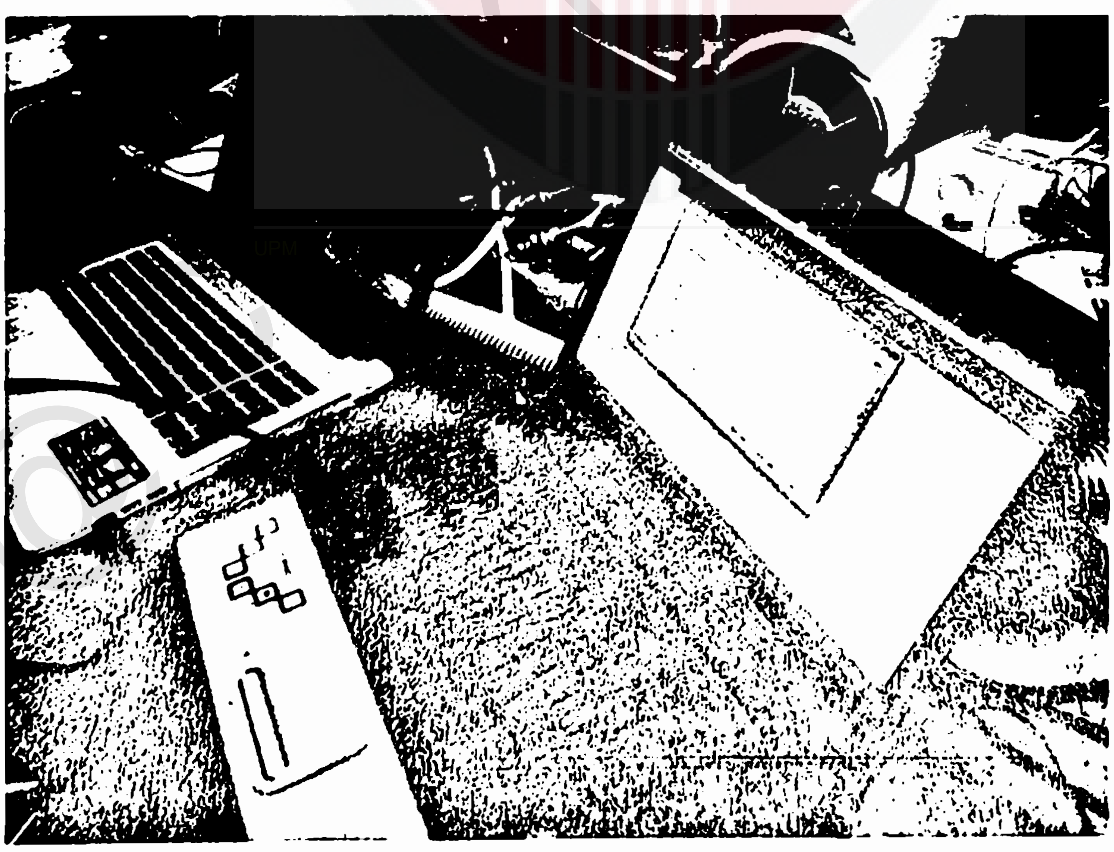


Figure 4.28: Programming process

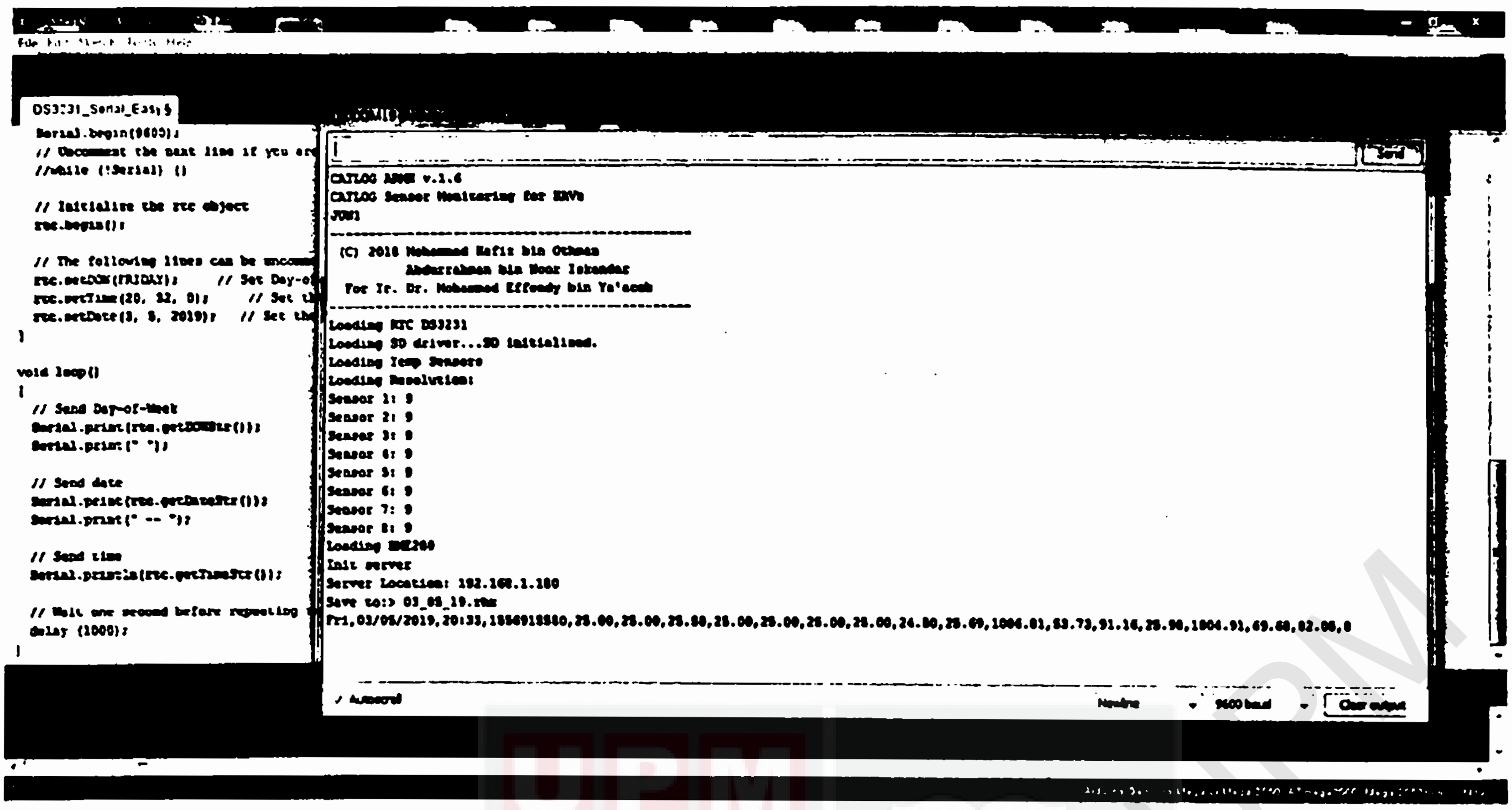


Figure 4.29: Finalize coding of the system

After the programming is finished, calibration process is done for 3 sensors which are temperature, humidity and flow rate. For temperature sensor, each of the sensors is calibrated by simply immerse in ice water to get constant zero degree Celsius (Figure 4.29). Humidity sensor calibration is using a method moist salt in enclosure containers for 12 hours. The expected constant value recorded is 75% relative humidity (Figure 4.30). While, the flow rate sensor is calibrated by pouring 1 liter of water within 1 minute and data recorded (Figure 4.31). The value recorded is 1088 pulse per minute. Thus, the flow rate obtained in experimental data will be divided with 1088 pulse per minute to get flow rate liter per minute.

Figure 4.30: Temperature sensor calibration

Figure 4.31: Humidity sensor calibration

Figure 4.32: Flow rate sensor calibration

4.2 Field observation on Plant growth

First week

During the first weeks of planting the Pak Choy, the crops need 4 days to adapt with new environment and media. The plant is monitored every day to ensure the plant save from pest and water level system work accordingly. The roots start to grow to reach water indicating it could adapt and survive. The real leaves grow is 4 to 5 only.

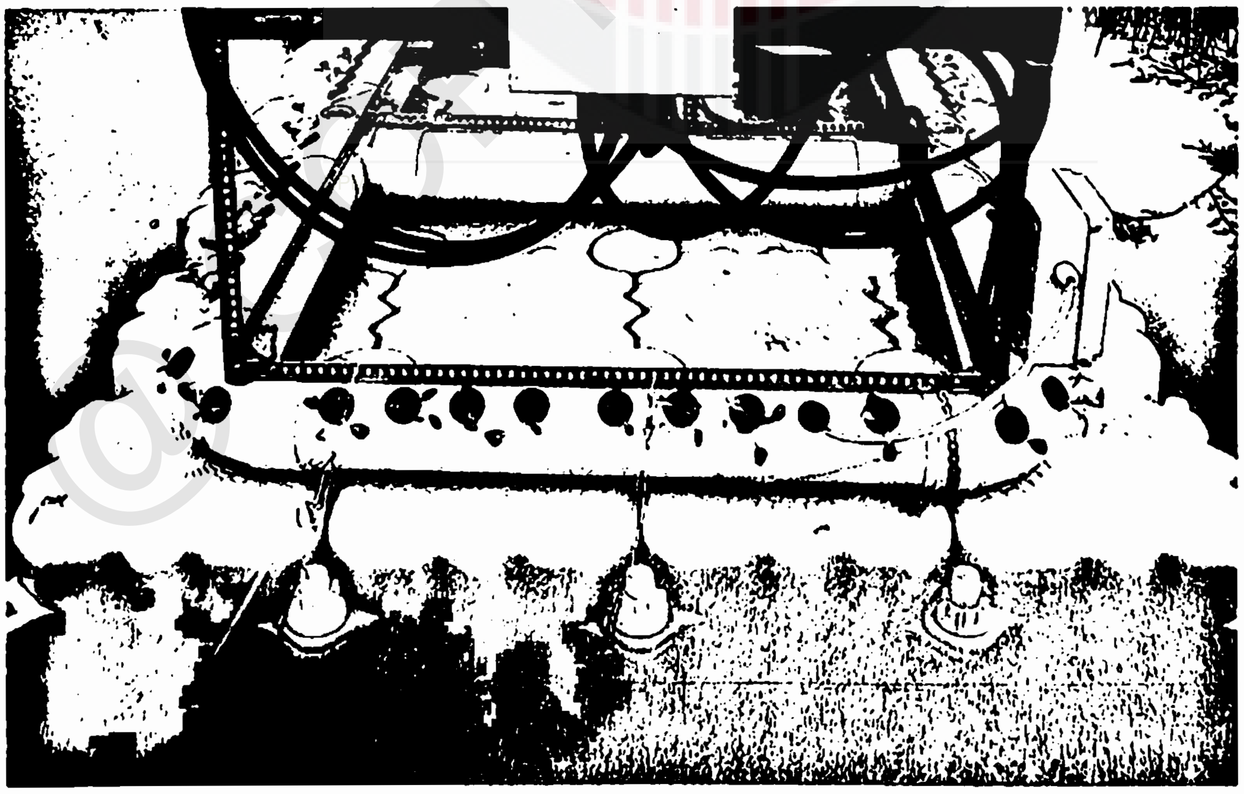


Figure 4.33: First week of transplanting

Second week

The started to grow well and leave multiples in between 7 to 9 leaves per plant. The roots are getting longer due to the plant needs of water and nutrients as 80 per cent composition of Pak Choi plant is water. There also pest disturbance happen in this phase and to encounter it, small amount of pesticide is sprayed on the plant.

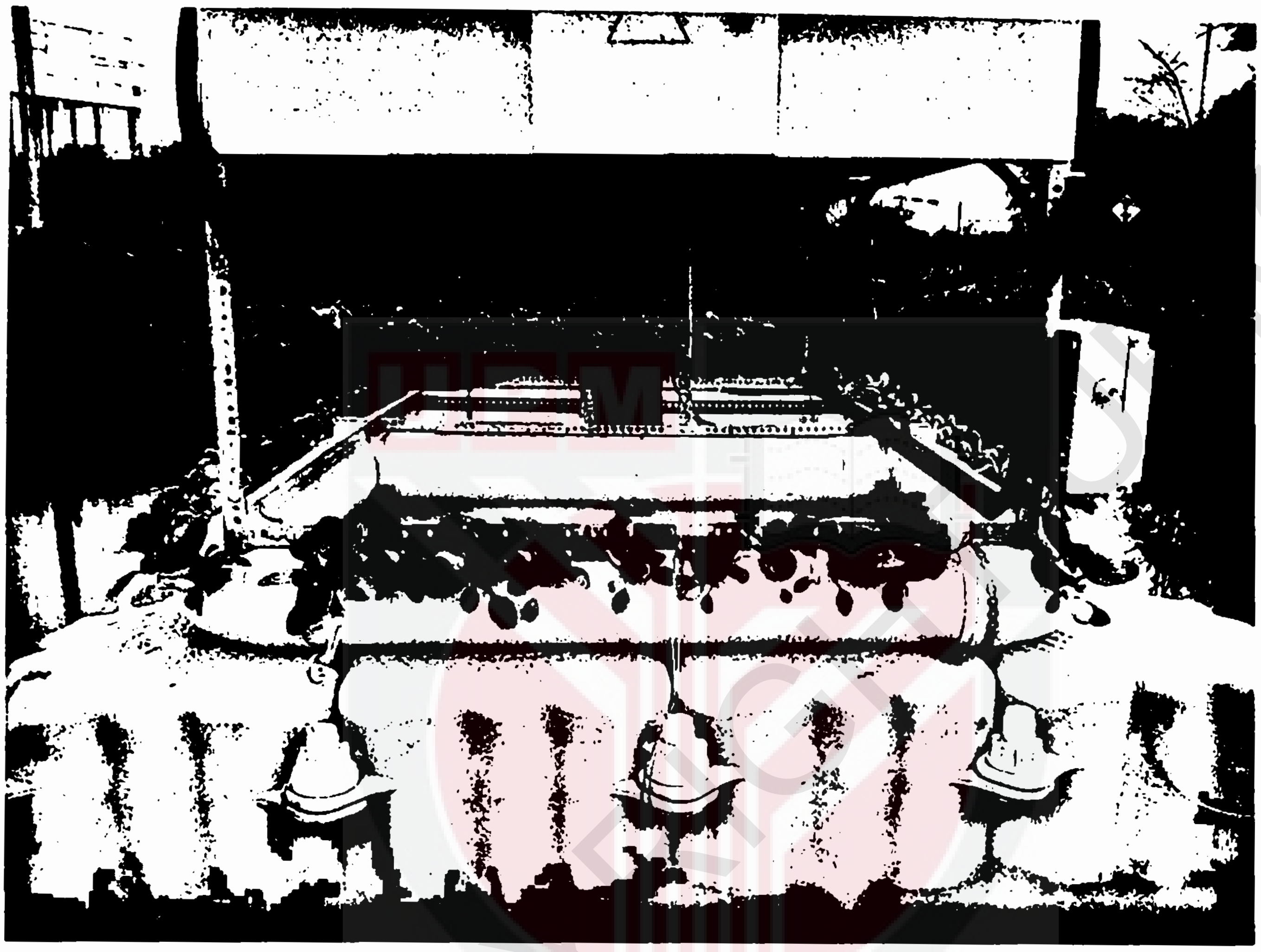


Figure 4.34: Second week of transplanting

Third week

The plant growth increase gradually after 3 weeks, where the leaves increases up to 13 leaves per plant nevertheless depends on the plant growth performance. There are few plants that is not grew as expected and stunted. It may be cause from the failure to adapt with new environment and the roots are not grown well.

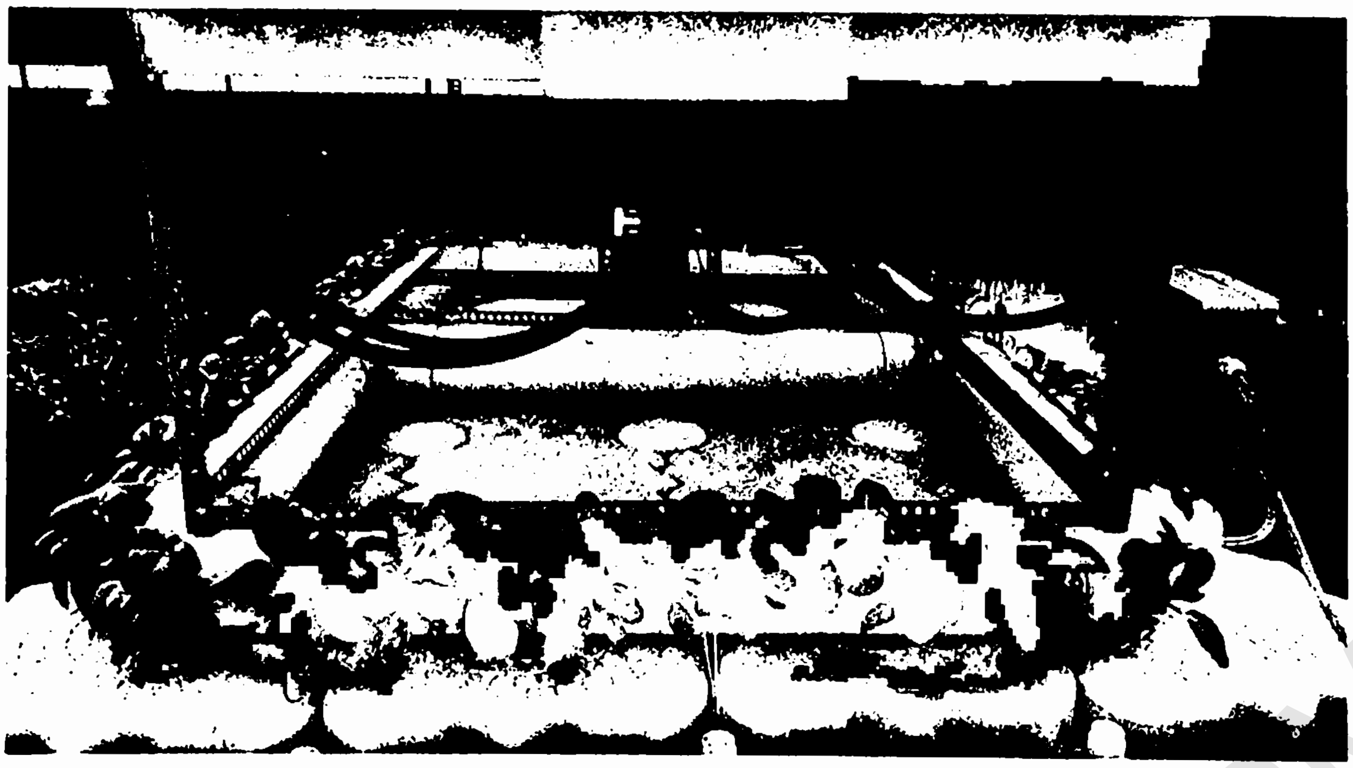


Figure 4.35: Third weeks of transplanting

Fourth week

The plant reached matured phases where it can be harvested. Based on observation, the plant that less expose to sunlight has bigger in size rather than the plant that almost all the time are expose to sunlight. Pest disturbance is occurred in this phase indicating the plant is safely consumed. Plant characteristic is obtained and data is tabulated in Table 4.3.

Figure 4.36: fourth weeks of transplanting

Figure 4.37: Harvested Pak Choi

Figure 4.38: Pak Choy plant

Figure 4.39: Weighing process of harvested Pak Choy

Figure 4.40: Measure the diameter of harvested Pak Choy

Table 4.3: Characteristic of harvested Pak Choy

Sample plant	Weight, g	Number of leaf	Diameter, cm	Height, cm	Shading area of planted (High, Medium)
1	99.48	26	24	23	High
2	82.60	24	34	22.4	High
3	65.40	26	29	22.5	Medium
4	75.45	23	30	24.7	High
5	66.40	23	29	22.5	Medium
6	37.66	15	26	21	Low
7	39.12	16	26	21	Low

Based on Table 4.3, the plant sample 6 and sample 7 have less weight compared to plant sample 1 and sample 2. It can be seen that the plant need an optimum level of sunlight exposure to ensure the growth is satisfied. Based on Figure 4.41, the plant sample 6 and sample 7 is grown at point A where the temperature is higher and most of the time point A is exposed to the sunlight compared to B. Plant sample 1 and sample 2 is planted at point B which it performed much better.

The limitation for this project is the movement of the Floatoponic is dominantly at Figure 4.41 positions as the Floatoponic need to be tight it to avoid it from move away from pond due to water overflow. The average weight of Pak Choy plant is 71.16 g. The average height is 23 cm. It shows that the plant height is adequate with the market standard height per plant which not more than 25.4 cm (Tuquero et. al., 2018).

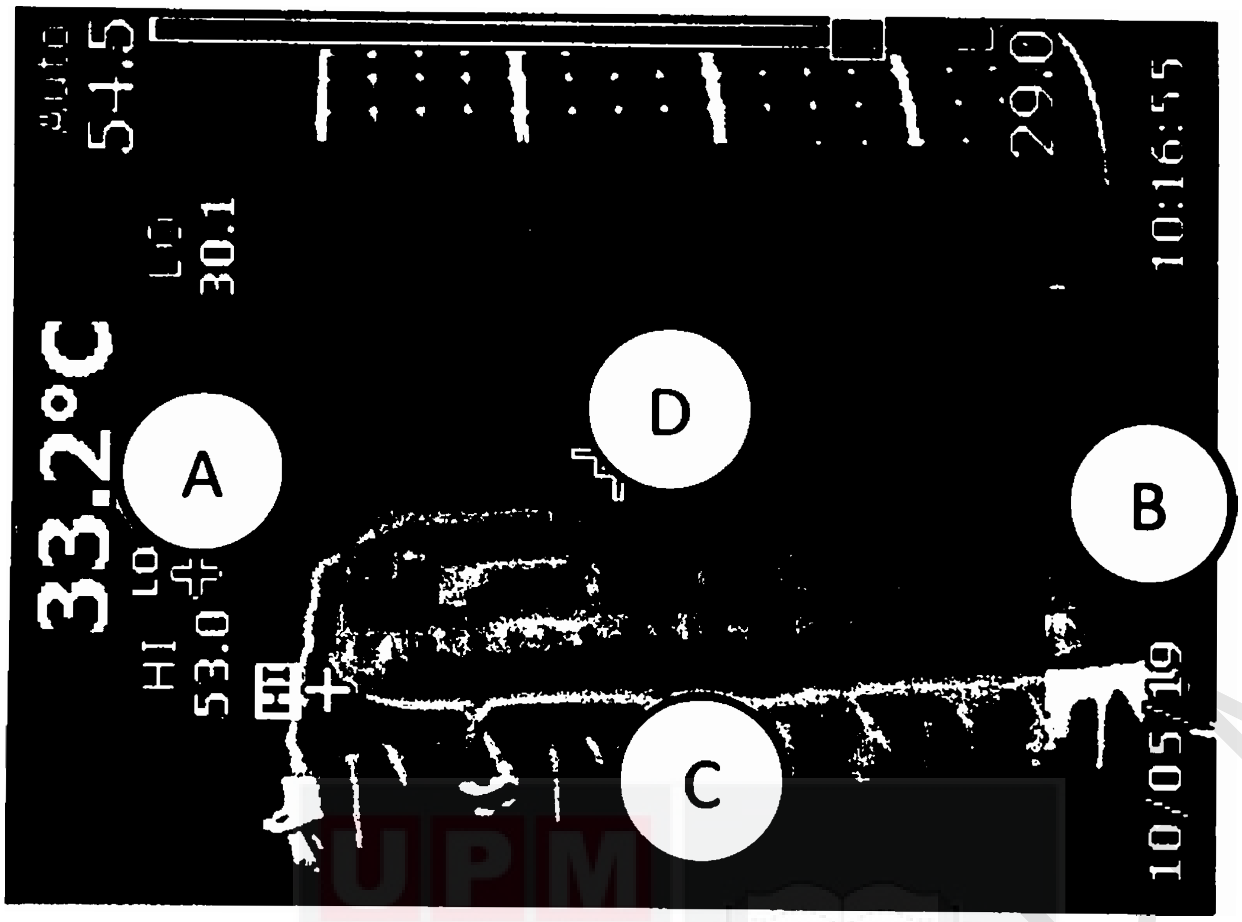


Figure 4.41: Temperature profile diagram of Floatoponic in morning

4.3 Temperature analysis

The temperature sensor is placed at different point on Floatoponic to analyse the temperature profile at specific part in Floatoponic. All 8 sensors are placed at different place which divide into 3 category of temperature (Ambient/environment temperature, water temperature and plant temperature).

Based on Figure 4.42, the temperature profile indicated ambient temperature or environment temperature. It shows that the temperature profile is significantly same for 3 days. Starting from 11 a.m., the temperature increased at 4 p.m. from 25^{O}C to 33^{O}C respectively. Then, it decline on 4 p.m. until 12 a.m. from 33^{O}C to 26 ^{O}C. From the result, it is clearly seen that the penetration of light is enough for the battery to store electrical energy for pump consumption. The maximum temperature is may exceed the range that the plant could withstand which is 30 ^{O}C. This might cause the plant to be stress and effect the growth.

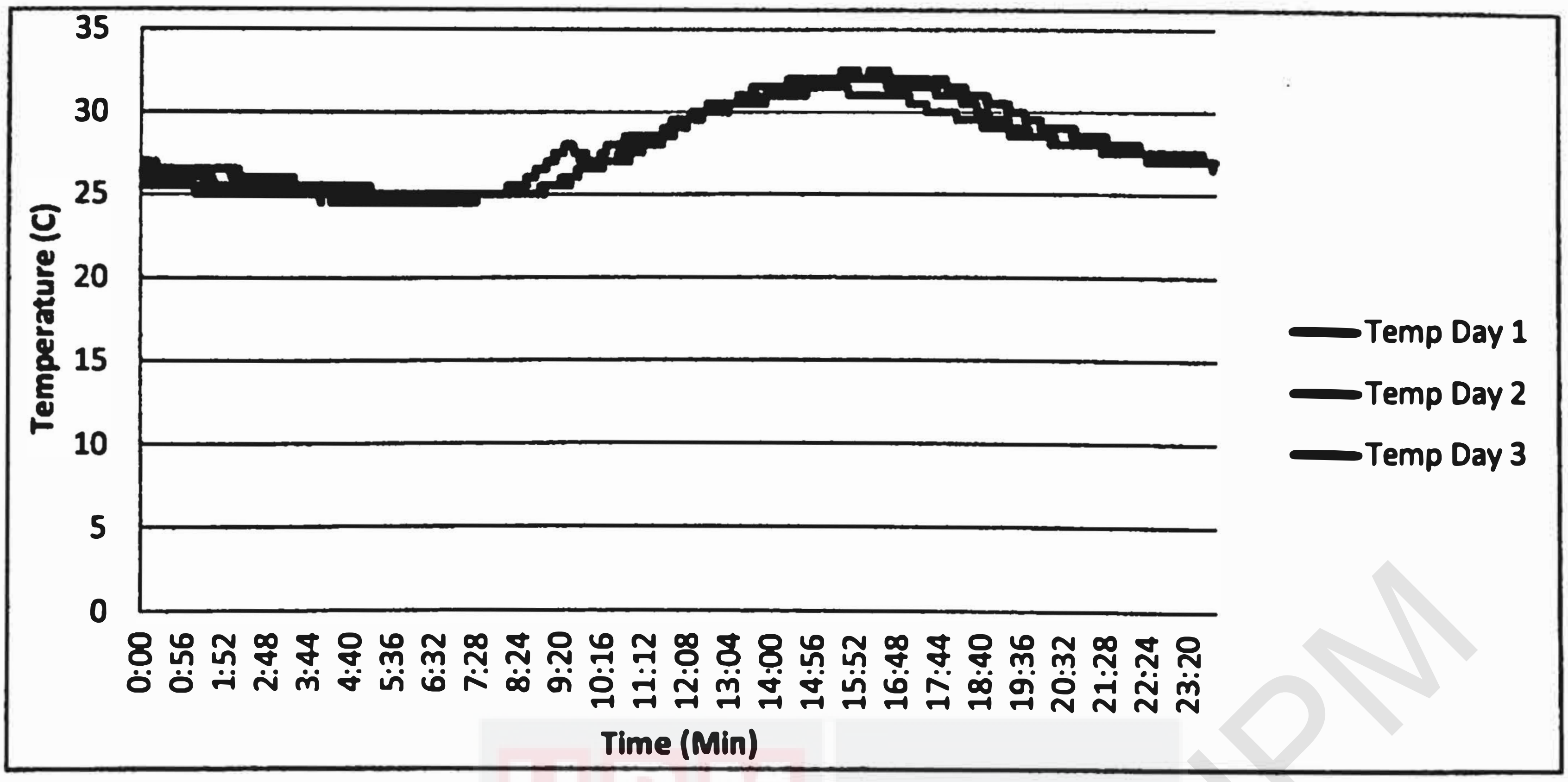


Figure 4.42: Temperature profile for ambient temperature

Figure 4.43 and Figure 4.44 show temperature profile of water at 2 different points. The water temperature is not similar like ambient temperature. The water temperature is increase and decrease in short interval and easily fluctuate especially temperature in point B. The water temperature is not homogenous through the growing tube, when the Floatoponic moving, the water with different temperature moves from part to part and the sensor detecting different temperature. The movement of Floatoponic is effected by the wind. The maximum water temperature in point A is around 39 °C while in point B is 38 °C

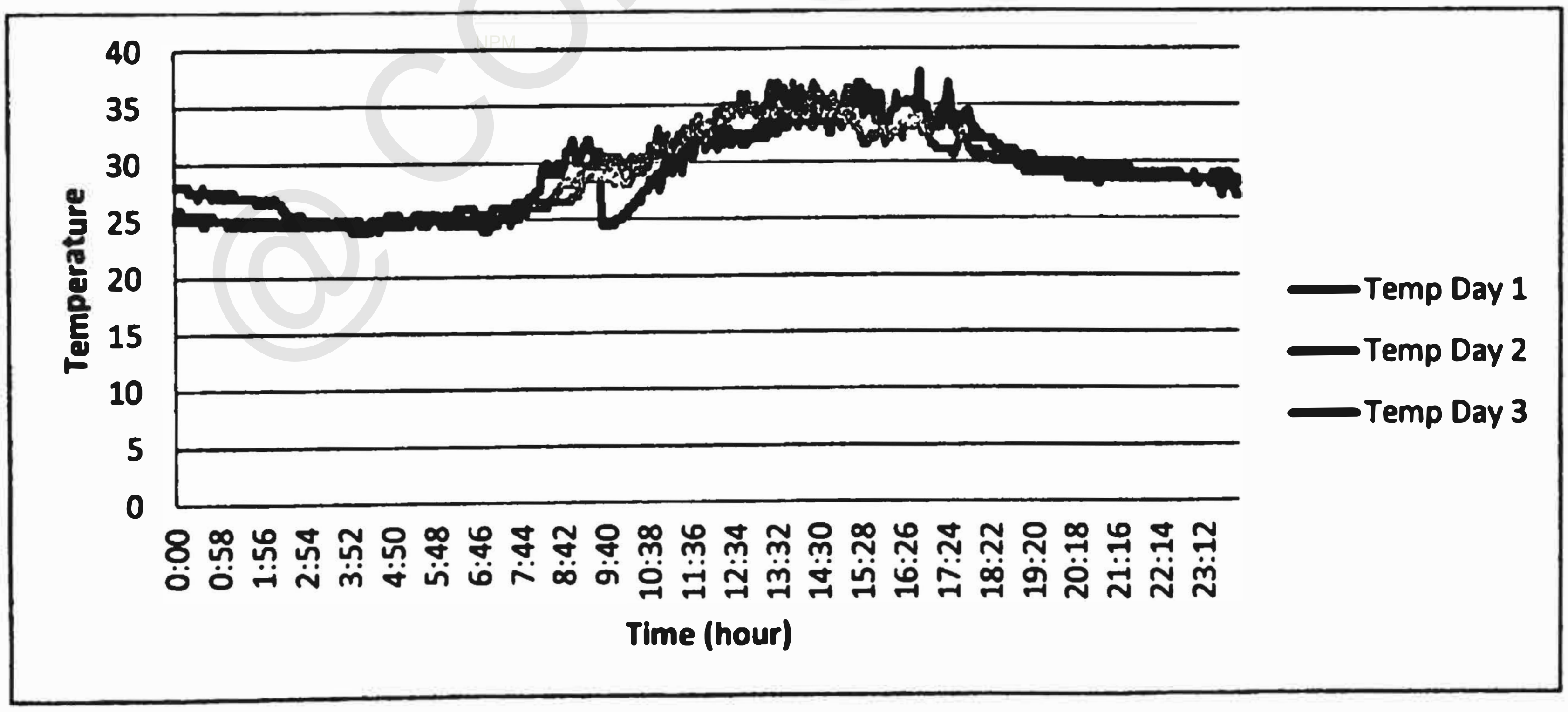


Figure 4.43: Temperature profile of water temperature (shading Point B refer figure 4.40)

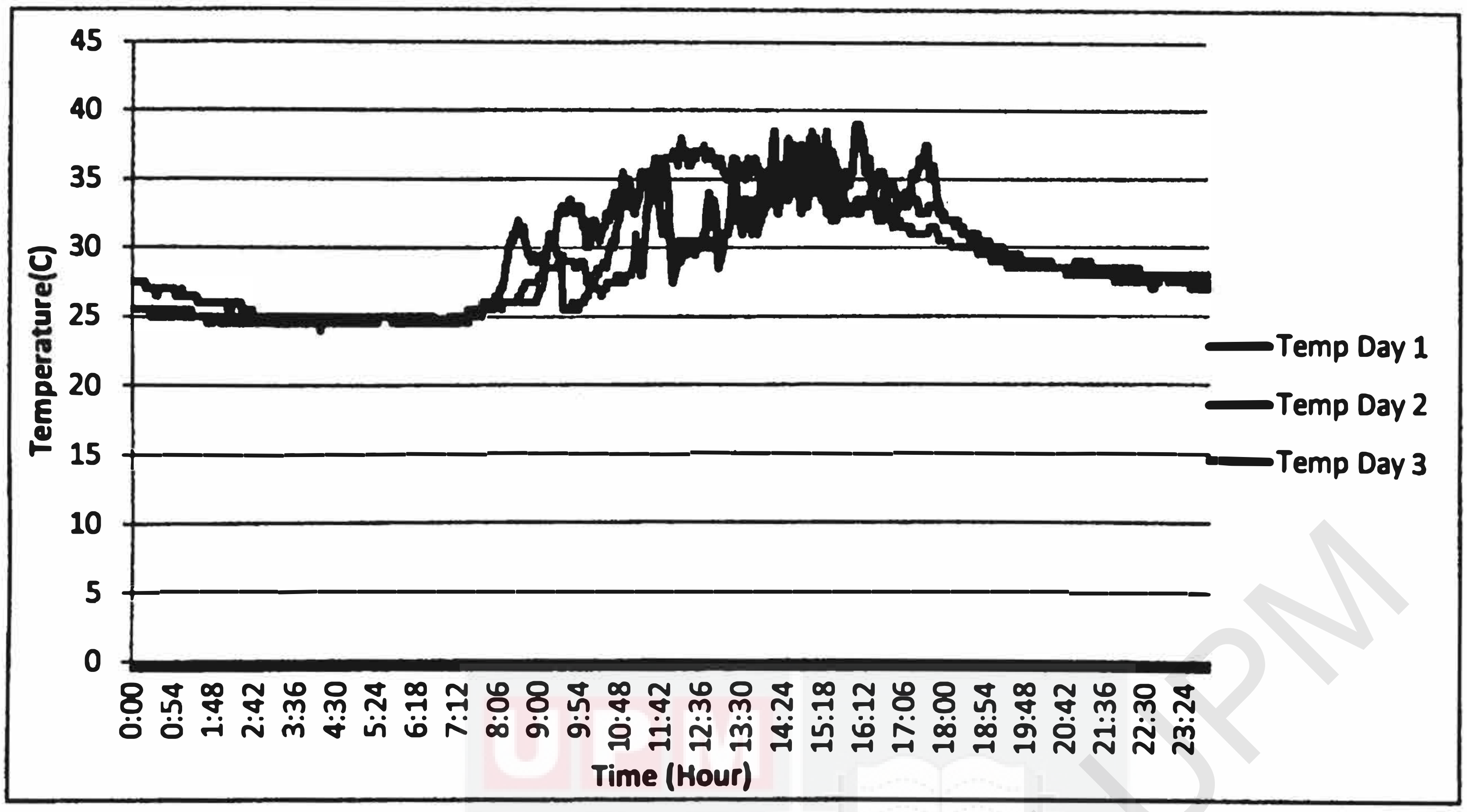


Figure 4.44: Temperature profile of water temperature (shading Point A refer figure 4.37)

By referring on the temperature profile shows in Figure 4.45, the maximum temperature for 3 days is not exceeding 34 ^{O}C and the minimum temperature is 24.5 ^{O}C. The maximum temperature at this point is affected by the morning light and not directly exposed to the sunlight. There are potential to utilize area under the Floatoponic with beneficial alternatives.

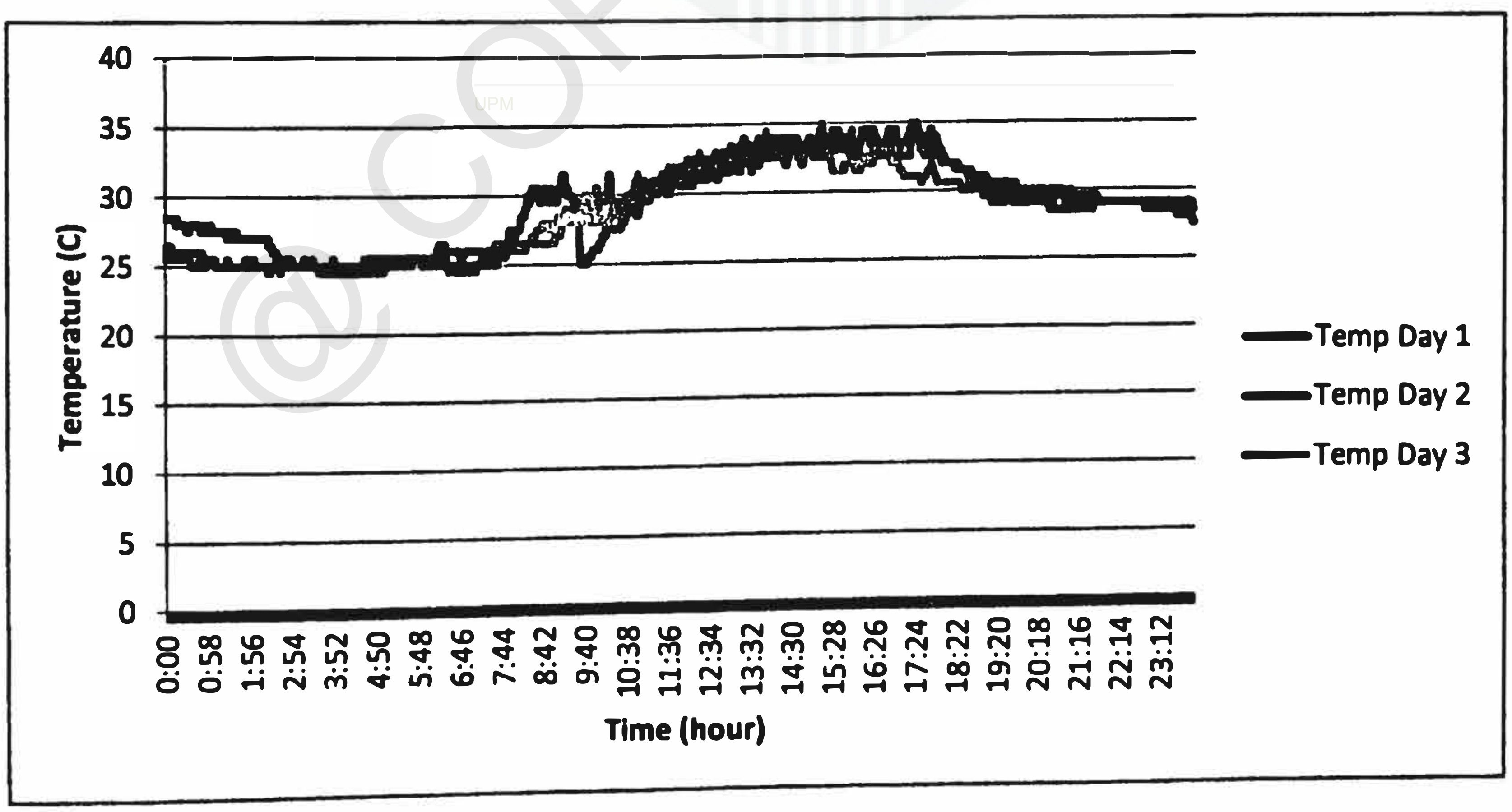


Figure 4.45: Temperature profile of middle under the Floatoponic

4.4 Humidity analysis

Based on the humidity profile in figure 4.46, the pattern is vice versa from temperature profile, when the temperature increases the humidity decrease. The maximum humidity can be reach is 90% and the minimum value is below 40%.

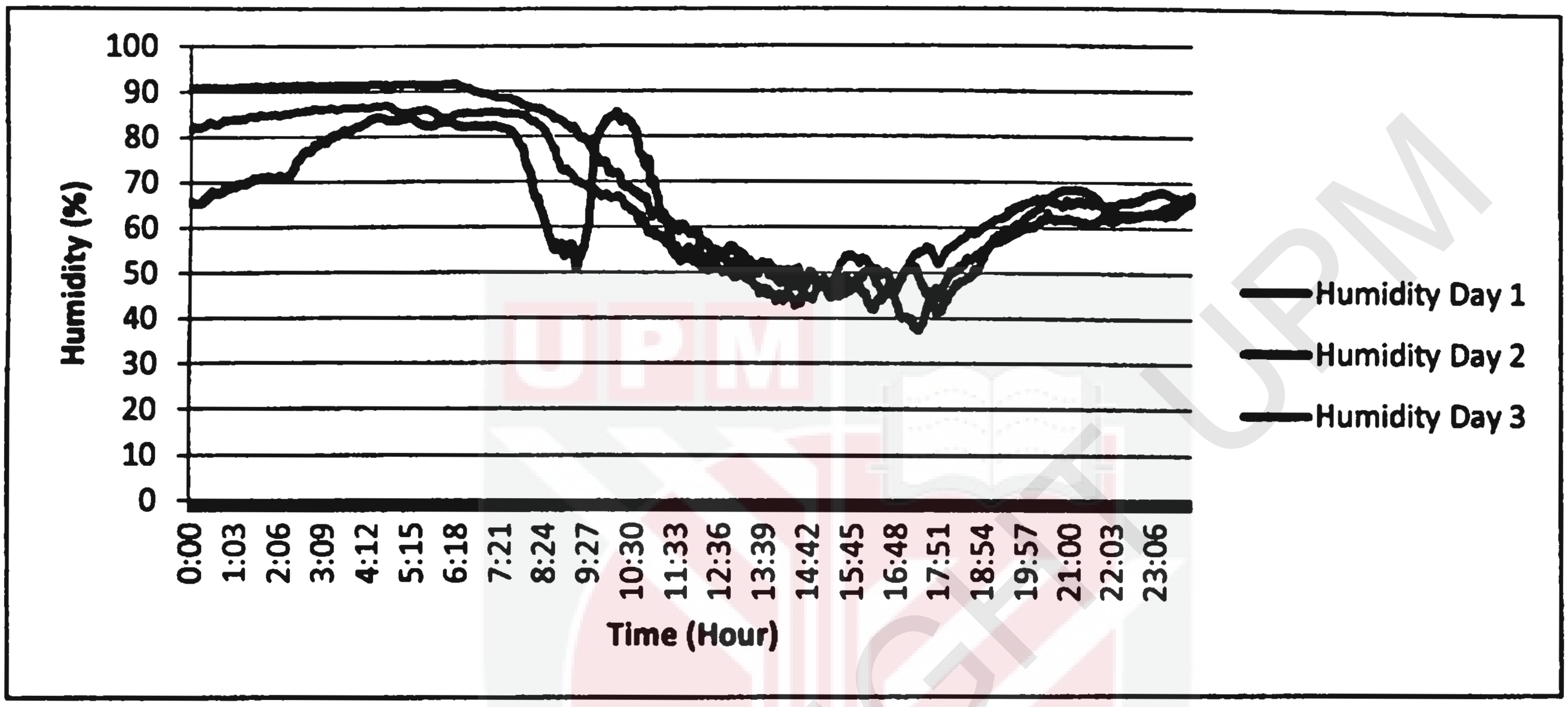


Figure 4.46: Humidity profile at ambient

Figure 4.47 show the humidity under the Floatoponic is fluctuated. The maximum humidity is 83% and the minimum is 48%.

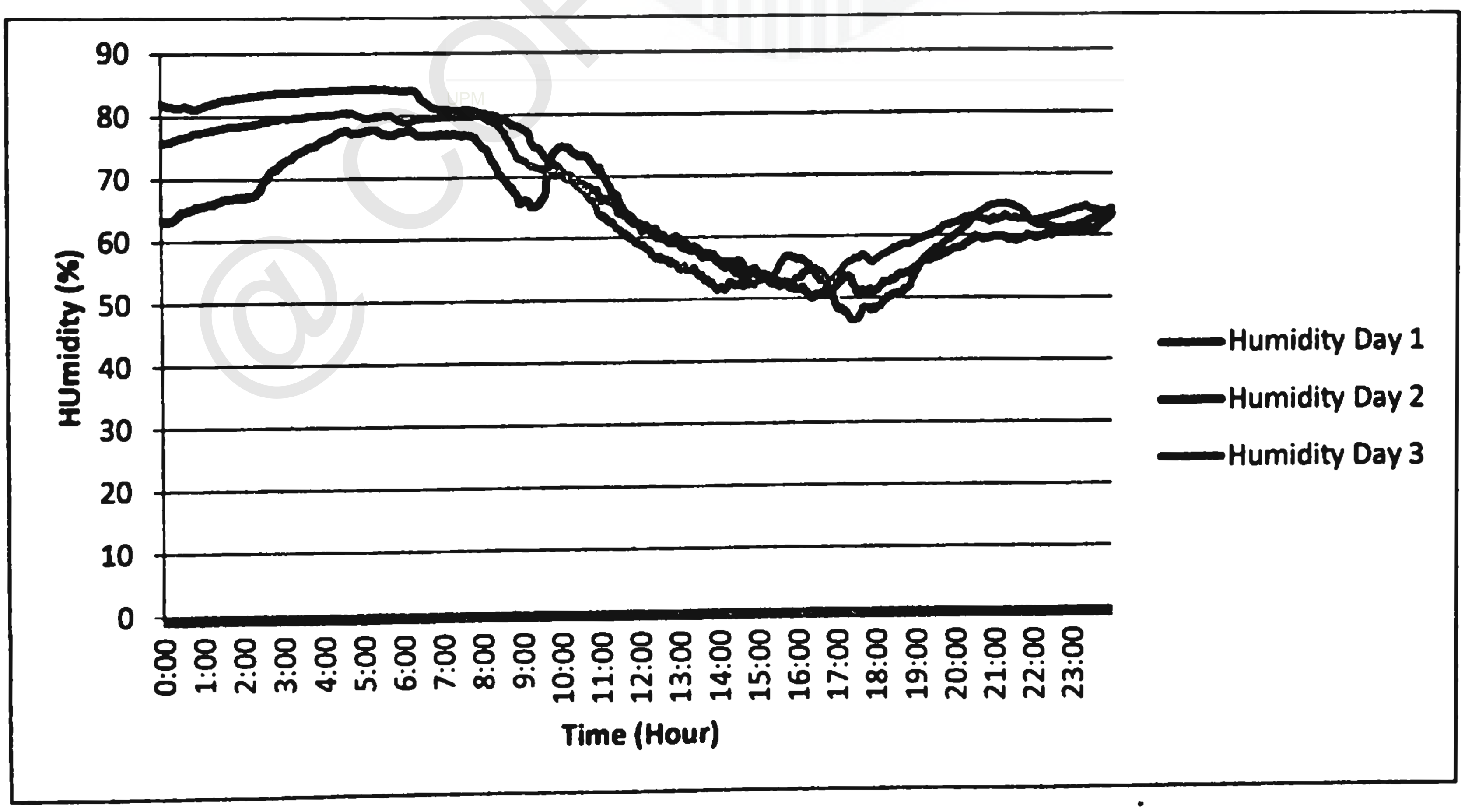


Figure 4.47: Humidity profile under Floatoponic

4.5 Flow-rate analysis

The water actively pumped into the growing tube within 7 a.m. to 7 p.m. The factor contribute for this result is based on the environment which from the movement of the Floatoponic driven by winds. Other than that, evaporation of water inside growing tube and water uptake by the plant also become the contribution factor. During day time, the plant is going through transpiration process thus increase the water uptake by the plant.

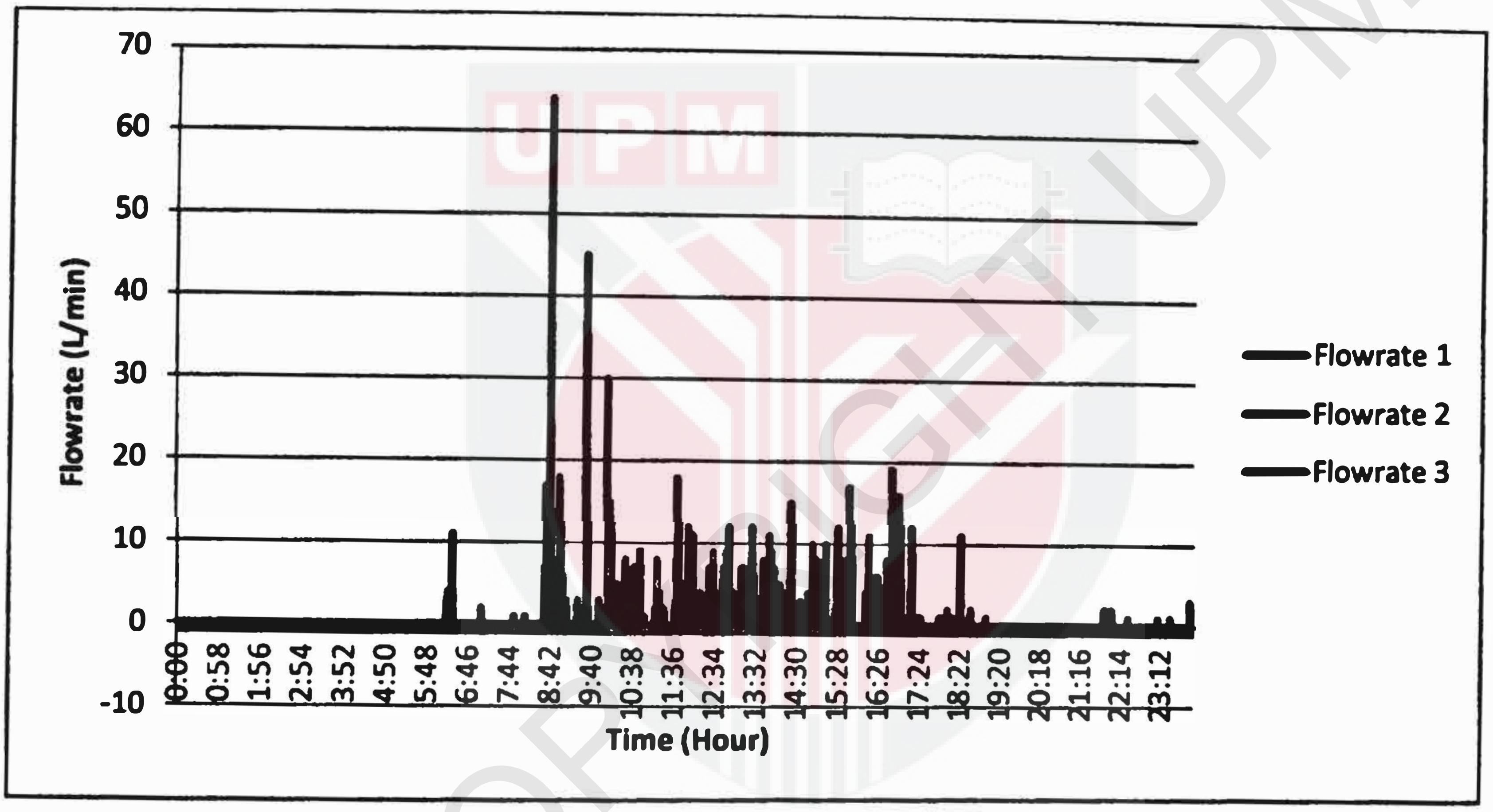


Figure 4.48: Flow rate of water pumped

Table 4.4: Flow rate and pump consumption

Day	Overall flow rate (L/min)	Total time obtained (min)	Pump consumption (kWh/day)
1	0.4605	110	7.92
2	0.3254	55	3.96
3	0.1333	20	1.44

Based on the pump power consumption, the values are not exceeding the capability of battery storage which can cause shortage. Thus, the volume of water inside the growing tube is acceptable.

4.6 Monetary Analysis

Table 4.5: Overall capital cost for hydroponic system

Detail	Price
Growing tube	RM90.00
Planting pot	RM45.00
AB fertilizer	RM25.00
Seeds	RM2.80
Media	RM8.00
Pump	RM69.00
Sensor	RM13.00
Miscellaneous	RM30.00
Total	RM283.00

Estimated Overall Weight = 4.86 kg

Market price = RM4

Revenue = RM 4 x 4.86 kg = RM 19.44 (for 54 plants)

Net profit = RM 19.44 – RM 11.80 = RM7.64

Payback period = 1.23 years

Based on the calculation above, monthly revenue of the crops is RM19.44 and the net profit is RM 7.64. The payback period is 1.23 years. Without the use of utilities such as water and electricity from the grid, the result is relevant as the consumption of water and electricity from grid could increase the operation cost which defeat profit.

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.0 Introduction

In this Chapter, the aim is to express the details that needed to be revised per conclusion of the project. Improvement also discussed in this chapter such that the project could be more relevant and potent for the future, hence able to help community and nations. This Chapter also issues details during project construction.

5.1 Conclusion

The project initiated from literature review, execution on plan and collected data research over the primary title. The scope of current knowledge is limited which driven attention to understand more on the related field to ensure project run successfully without error. The area of study may consider electrical, mechanical and agriculture aspects to complete the systems.

Different approach is analysed in literature review to find out the best method and material. Problem might happen through the completion process which needs to prepare counter measure to make sure project is on tract.

To giving conclusion, the project can work successfully and improvement has to be done to minimize the weight of Floatoponic yet can last long to obtain a payback. Thus the project has high potential to be commercialize to large scale and can be collaborate with related body.

5.2 Recommendation

Obviously there are some issues that need to be addressed and required further study concerning the structure and overall system of Floatoponic. The overall performance is resulting satisfied outcomes.

It is recommended to evaluate the structure of the Floatoponic to meet the existing Floating PV structure. Monetary evaluation of the system have to be further detailed thus can prove the beneficial factor in term of cost and revenue.

Future planning for the Floatoponic is commercialized into medium scale. Since Faculty of Engineering has lake that not being utilize for other purposes, the project is currently planned to be implement in Faculty Engineering Lakes. The expected power generate is 300kW. Beside it can be one of the attractions in Fakulti Kejuruteraan.

Figure 5.1: Aerial view of the Floatoponic installation

Figure 5.2: From library view of the Floatoponic installation

Monetary Benefits

Estimated crops produce = 60.68 kg

Revenue = RM 4 x 60.68 kg = RM 242.80

Mushroom cultivation under Floatoponic

Based on the temperature profile under the Floatoponic, the temperature is favourable for mushroom growing. The required condition for the mushroom to grow; temperature between 28°C to 30 °C and humidity 80% to 90%

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