ECO-DRAINAGE SYSTEM TOWARDS SUSTAINABLE URBAN ENVIRONMENT

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CERTIFICATION OF APPROVAL

Eco-Drainage System Towards Sustainable Urban Environment

by

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Approved by,

(Assoc. Prof. Dr. Nasiman Sapari)

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JUNE 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NURFISAH BINTI SHAMSUDDIN

ABSTRACT

Sustainable urban drainage is a concept that includes long-term environmental and social factors in the planning and design of drainage systems. The function is to manage the stormwaters in developments that replicate the natural drainage. The project is to develop the drainage system to support an aquatic life that promotes balance ecosystems and at the same time examines the best infiltration devices based on the condition at the residential area in Bandar Seri Iskandar, Perak. Infiltration is the process by which water on the ground surface enters the soil. Infiltration rate in soil science is a measure of the rate at which soil is able to absorb rainfall or irrigation. Based from the studies explained that the infiltration device was suitable to be implemented at the site area of Sri Iskandar. The purpose of the infiltration device was to take off runoff water from development and allows it to percolate into the ground. It reduced the volume of water that has to be disposed of through sewers and then recharge of groundwater to maintain water level in local watercourses. From the result, there were some improvement in the water quality elements such as turbidity, pH value, COD, BOD_5, DO, Ammonia Nitrogen and Total Phosphorus. For the turbidity the percentage of removal was 11.63%, COD reduce to 39.29%, BOD reduce to 25.16%, Ammonia Nitrogen reduce to 9.68% and Total Phosphorus reduce to 9.86%. This project was still under development phase where there will be some requirements and aspects that need to be addressed of.

ACKNOWLEDGEMENT

In the name of Allah, the Gracious, the Merciful, I would like to thank Him for giving the strength, skill, knowledge, patience and good health in producing this report. The greatest pleasure in writing such report is when it comes to acknowledge the efforts of many people whose names may not appear on the cover, but without their hard work, cooperation, support and understanding, producing this report would be impossible.

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ABBREVIATIONS

BMPs	Best Management Practices
COD	Chemical Oxygen Demand
INWQS	Malaysian Interim Water Quality Standard
NTU	Nephelometric Turbidity Unit
NQWS	National Water Quality Standard, Malaysia
TSS	Total Suspended Solids
USDA	U.S Department of Agriculture

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Sustainable urban drainage is a concept that includes long-term environmental and social factors in the planning and design of drainage systems. The function is to manage the stormwaters in developments that replicate the natural drainage. The objective of this project is to develop the drainage system to support an aquatic life that promotes balance ecosystems and at the same time examines the best infiltration devices based on the condition at the residential area in Bandar Seri Iskandar, Perak.

1.1 Background of Study

Sustainable Drainage Systems (SuDS) or known as Sustainable Urban Drainage Systems (SUDS) are designed to reduced the potential impact of new and existing developments with respect to surface water drainage discharge. The objectives of this approach is to prevent pollution, to control flooding which may occurred in the downstream and to use the stormwater to recharge into groundwater. It also provides other environmental benefits such as aquatic life ecosystems, improved aesthetics or community resource.

A SUDS is made of one or more structures built to manage surface water runoff. Runoff is collected and stored to allow natural cleaning to occur prior infiltration or controlled released to watercourse. SUDS techniques allow natural drainage to function in the landscape surrounding development. Generally, there are four general design options that are filter strips and swales, filter drains and permeable surfaces, infiltration devices, and basins and ponds. In order to control the possibility of pollution and flooding, one of these designs might be proposed at selected location of the study area.

Stormwater is the flow of water, which results from precipitation and occurs immediately after rainfall. When a rainfall occurs, several things can happen to the precipitation. Some of the precipitation infiltrates into the soil surface, plants take some up and some is evaporated into the atmosphere. Stormwater is the rest of precipitation that runs off land surfaces and impervious area. Stormwater discharges are generated by precipitation and runoff from land, pavements, building rooftops and other surfaces. These hardened surfaces are called 'impervious surfaces' and they do not allow rainfall to infiltrate into the soil surface like natural vegetation, so more of the rainfall becomes stormwater runoff. Stormwater runoff accumulates pollutants such as oil and grease, chemicals, nutrients, metals, and bacteria as it travels across land. Heavy precipitation can also cause sewer overflows that may contaminate water sources with untreated human and industrial waste, toxic materials, and other debris. (Butler, D., & Davies, J.W. et al., 2004).

Sustainable drainage systems will generally discharge water in one of three ways. The Building Regulations Approved Document H (DTLR, 2002) lists the discharge options in order or priority which are :

1. Infiltration to the ground via a soakaway or other system which will ultimately reach groundwater.
2. Discharge to a watercourse of other surface water.
3. Discharge to a sewer.

Flow control and temporary storage of runoff is effective in reducing flooding where it occurs.

1.2 Problem Statement

1.2.1 Problem Identification

Nowadays, Malaysia has been widely practicing rapid disposal, localized, reactive and mono-functional drainage concepts. The traditional approached widely practiced in Malaysia is to allow developers to put in drains where the location is appropriate. Furthermore, the architect has more or less to put alignment for drainage after packing in the most number of housing units allowable in the area. For the moment, the engineer's job is only to determine drain size to comply with drainage capacity and final discharge outlet requirements. So to further maximize housing density, developers normally channel all drainage to one large trunk drains. All drains connected to trunk drains are normally concrete-lined and of the open channel type to minimize the land area required. (Embi, A.F & Kassim, A. H. et al., 1998).

Previously in Malaysia, urban drainage practice has been on the 1975 DID Urban Drainage Design Manual that covers essentially the planning, basis of design, flood discharge, hydraulic design of open channel, structures, storm drainage for urban streets, detention storage, erosion and sediment control and information to be submitted with design. The approaches to the design procedure, in term of method and techniques employed, have not been reviewed and upgraded although advances in urban drainage and urban storm water management technology are widely being practiced in overseas such as United Kingdom, United States, Germany, Australia and Japan. (MASMA, 2000)

Surface water drainage from urban developed area is increasingly affecting the river catchments. As development intensifies, so more water runs rapidly into rivers and less filters through the soil. This sealing of the ground can and does lead to localized flooding and water pollution, and will only get worse as our climate changes. We need a new approach to drainage that keeps water on site long, prevents pollution and allows storage and use of the water at the same time also support aquatic life that promote balance of eco-system.

Drainage in urban environment often becomes breeding place to mosquito. The mosquito always breeding in the sand trap where there is some water contain in the space. Therefore, the greatest risk of infection occurs during prime mosquito season and under ideal breeding conditions, which vary for different species. Mosquitoes breed faster when temperatures are high. Low temperatures and low humidity cause slow breeding and higher mortality rates. When the temperature drops, mosquitoes are less prone to transmit disease. (Smith Reynolds Z. Foundation et al., 2009)

1.2.2 Significant of The Project

The design of sustainable urban drainage systems (SUDS) is based on principles of ecological engineering, which aims to preserve natural drainage patterns and emulate the natural hydrological cycle. Some technologies such as swales and constructed wetlands incorporate the use of vegetation technique, which improves the quality of storm water runoff by trapping suspended solids and related pollutants.

1.3 Objectives

The objectives of this project are:

1. To develop the drainage system to support an aquatic life which promote balance ecosystem.
2. To evaluate the effectiveness of the eco-drainage system toward pollutants removal.
3. To construct the model of the eco-drainage system based on the condition at the residential area in Bandar Seri Iskandar, Perak.

1.4 Scope of Study

This project consists of the Best Management Practices (BMP's) in stormwater management that has been implemented in several countries around the world. The main focus of this project based on the environmental aspects of stormwater quality and quantity control that needs to be balanced against the hazard and nuisance effects of flooding.

During the first stage, the main objective is to collect and gather as much relevant information from previous research and at the same time try to understand the concepts of Best Management Practices for Eco-drainage systems. For the time being the objective is to collect and analyze the quality of runoff water and stormwater in a period of time.

The next stage is to evaluate the effectiveness of eco-drainage system by comparing water samples from drains that are polluted against the natural water sample. Figure 1.1 shows the existing drainage system at the project area.

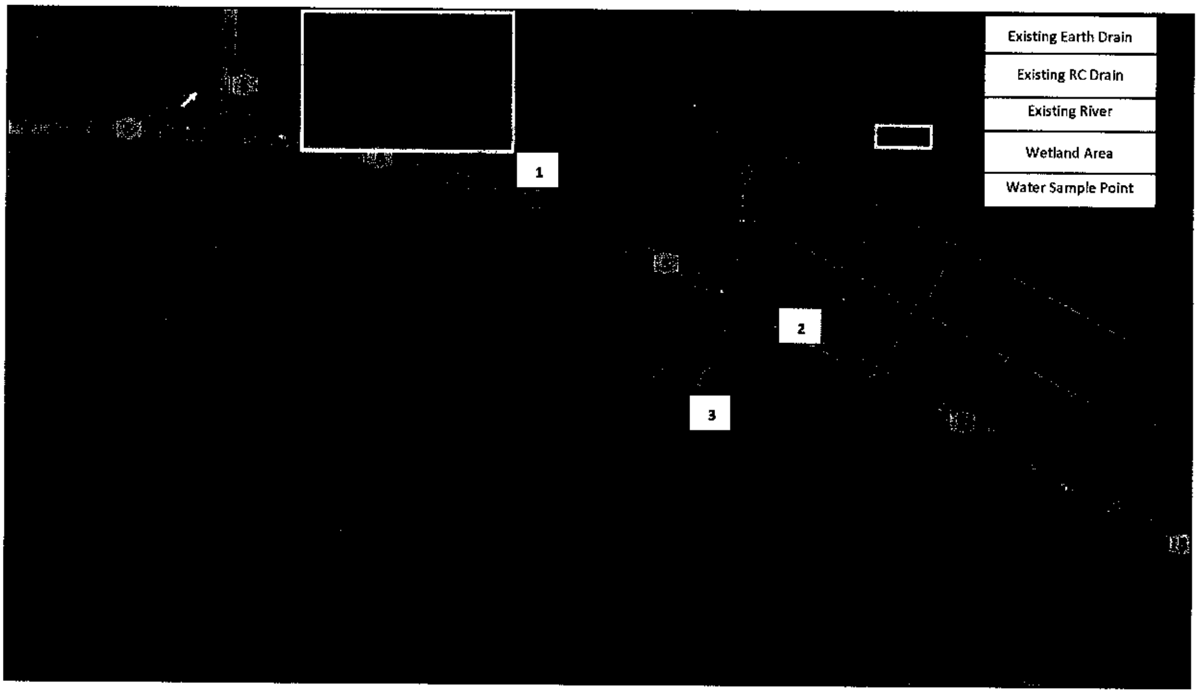

Figure 1.1: Existing drainage system in Bandar Seri Iskandar.

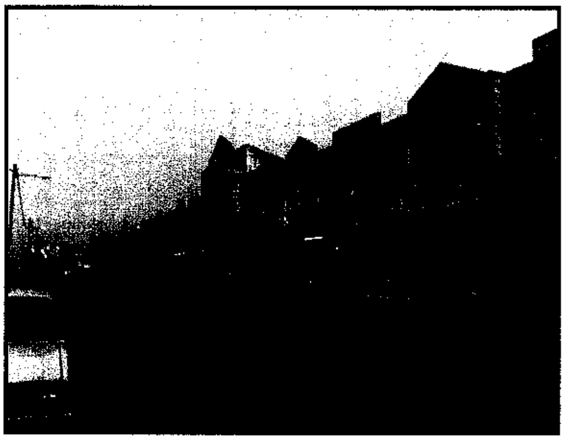

Figure 1.2: Shophouses at Sri Iskandar

Figure 1.3: Shophouses opposite the main road at Sri Iskandar

Figure 1.4: Drainage system located near shophouses

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 Ecosystem

The term ecosystem refers to the combined physical and biological components of an environment. An ecosystem is generally an area within the natural environment in which physical (abiotic) factors of the environment, such as rocks and soil, function together along with interdependent (biotic) organisms, such as plants and animals, within the same habitat. Ecosystems can be permanent or temporary. Ecosystems usually form a number of food webs.

An ecosystem can be divided into living and non-living components. The living organisms can be further divided into producers, consumers, and decomposers. Plants are example of producers, fishes are examples of consumers that feed directly on plants and decomposers include bacteria and fungi. The non-living components of the system are classified as chemicals and defined by energy a material flows. These classifications are shown in Figure 2.1.

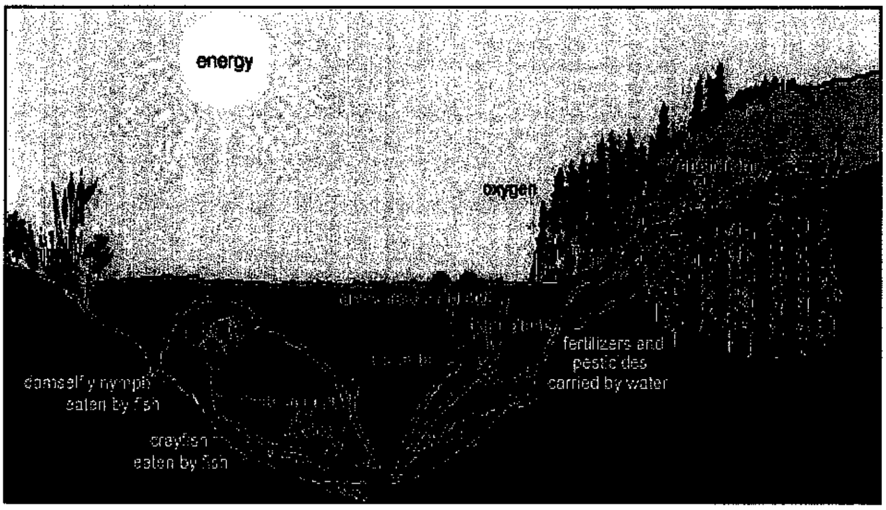

Figure 2.1: The aquatic animal cycle
(Source: Mitsch and Gosselink, 2000)

2.2 Best Management Practices (BMPs) In Stormwater Control

According to Parkinson and Mark (2005), stormwater best management practices (BMPs) are control measures taken to mitigate changes to both quantity and quality of urban runoff caused through changes to land use. Generally BMPs focus on water quality problems caused by increased impervious surfaces from land development. BMPs are designed to reduce stormwater volume, peak flows, and/or nonpoint source pollution through evapotranspiration, infiltration, detention, and filtration or biological and chemical actions.

2.3 Clean Water Act 1972

The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. Its principle intent was to ". . . *restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101). To accomplish that objective, the act aimed to attain a level of water quality that "provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water*" by 1983 and to eliminate the discharge of pollutants into navigable waters by 1985. (APHA., 1998)

2.4 Drainage Systems

According to Butler and Davies (2004), drainage systems are needed in development urban areas because of the interaction between human activity and the natural water cycle. There are two main forms of interaction for the drainage systems which are the abstraction of water from the natural cycle to provide a water supply for human life, and the covering of land with impermeable surfaces which divert the rainwater away from the local natural system of drainage. The interaction gives rise to types of water that require drainage which are wastewater and stormwater. Development of an urban area, involving covering the ground with artificial surfaces, has a significant effect on these processes. The artificial surfaces increase the amount of surface runoff in relation to infiltration, and therefore increase the total volume of water reaching the river during or soon after the rain. Surface runoff travels quicker over hard surfaces and through sewers than it does over natural surfaces and along natural streams. It means that the flows will both arrive and die away faster and therefore the peak flow will be greater. The impact is obviously increases the danger of sudden flooding of the river. It also has strong implications for water quality. The rapid runoff of stormwater is likely cause to pollutants and sediments to be washed off the surface or scoured by the river. Drainage systems in which mixing with wastewater and stormwater may allow pollutants from the wastewater to enter the river.

2.5 Increased Runoff and Pollutant Loads

United State Environmental Protection Agency (USEPA, 2009) mentioned that in urban and suburban areas, buildings and pavement cover much of the land surface, which does not allow rain and snowmelt to soak into the ground. Instead, most developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. The stormwater runoff carries pollutants such as oil, dirt, chemicals and lawn fertilizers directly to streams and rivers, where the seriously harm water quality. Development should be design and built to minimize increases in runoff to protect surface water quality and groundwater resources. The porous and varied terrain of natural landscape like forests, wetlands, and grasslands traps rainwater and allows them to filter slowly into the ground. Storm sewer systems concentrate runoff into smooth and straight conduit. When runoff leaves the storm drains and empties into a stream, the volume and power blast out stream banks, damaging streamside vegetation and wiping out aquatic habitat. The loss of infiltration from urbanization may cause profound groundwater changes. Many native fish and other aquatic life cannot survive when these conditions prevail.

From the research by United State Environmental Protection (USEPA, 2009), urbanization also increases the variety and amount of pollutants carried into streams, rivers, and lakes. From the development and construction, it produced pollutants such as sediment, oil, grease, toxic chemicals from motor vehicles; pesticides and nutrients from lawns and gardens; viruses, bacteria, nutrients form pet waste and failing septic system into the storm drainage systems. These pollutants can harm fish and wildlife populations, kill native vegetation and foul drinking water supplies.

2.6 On-Site and Off-Site Technologies for Runoff Control

The choice of technologies adopted will be driven by a number of factors including type and size of development, physical and environmental constraints and sensitivity of receiving waters. Some technologies such as swales and constructed wetlands incorporate the use of vegetation that improves the quality of stormwater runoff by trapping suspended solids and related pollutants. (Parkinson, J., & Mark, O. et al., 2005)

According to Girling (2000), vegetation has important function in the natural water cycle storing water by interception on leaf surfaces and water uptake by plants. Good root structure breaks up soils increasing permeability and allowing water to infiltrate. The use of vegetation as well as contributing towards runoff and pollution control at the same time contributing towards the preservation of natural habitats for aquatic life.

2.7 Infiltration of Stormwater

Infiltration is the process by which water on the ground surface enters the soil. Infiltration rate in soil science is a measure of the rate at which soil is able to absorb rainfall or irrigation. It is measured in inches per hour or millimeters per hour. The rate decreases as the soil becomes saturated. If the precipitation rate exceeds the infiltration rate, runoff will usually occur unless there is some physical barrier. It is related to the saturated hydraulic conductivity of the near-surface soil. The rate of infiltration can be measured using an infiltrometer.

Martin et al. (2000) reviewed that direct infiltration into the ground is an important source control strategy for stormwater management. Infiltration of uncontaminated runoff from rainfall reduces the volume and rate of runoff and recharges groundwater. At the same time it also helps maintain base flows in rivers and provide sources of water supply. In addition, infiltration facilities should no be located near to septic tanks or building foundations.

Robert et al. (1933) suggested that infiltration capacity rapidly declines during the early part of a storm and then tends towards an approximately constant value after a couple of hours for the remainder of the event. Previously infiltrated water fills the available storage spaces and reduces the capillary forces drawing water into the pores. Clay particles in the soil may swell as they become wet and thereby reduce the size of the pores. In areas where the ground is not protected by a layer of forest litter, raindrops can detach soil particles from the surface and wash fine particles into surface pores where they can impede the infiltration process.

2.8 Vegetated Swales

Mohd Sidek (2002) defined swales are vegetated, open channels that have a dual function to control runoff. The purpose of swales is to promote infiltration and at the same time, the vegetation also reduces flow velocity in the channel due to high roughness in the runoff. Grass swales are being employed in developed countries as flow and quality control measure. From the research, grass swales showed good performance for removal of large particles such as suspended solids and pollutants attached to solids such as phosphorus. Vegetated swales are broad, shallow channels with a dense stand of vegetation covering at the side slopes and channel bottom. Dry swales are used in areas where standing water is not desired, such as in residential areas. Wet swales can be used where standing water does not create a nuisance problem and where the groundwater level is close enough to the surface.

2.9 Constructed Wetland

According to CIRIA (2004), constructed wetlands are specifically constructed to treat pollutants in runoff and comprise a basin with shallow water and aquatic vegetation that will provides biofiltration. Constructed wetlands are being used to manage urban stormwater with the objectives of runoff control and water quality improvement. It also has landscape and amenity value, improving the aesthetical value of the urban environment and providing a natural habitat for flora and fauna. For the purpose to improve pollutant removal mechanisms by various processes including filtration, infiltration and biosorption, constructed wetlands are planted with vegetation.

The various issues and performance considerations associated with wetlands for stormwater pollution control. The detention time is commonly used to estimate the performance of these facilities as pollution control systems. (Wong, T. H. F., Breen, P.F. & Somes, N. L. G. et al., 1999)

Wetlands can be designed so as to deter mosquito breeding by ensuring the residence time is only a few days so the larvae do not have time to grow. In addition, various biological controls can be employed to control the insect population and these are preferred over chemical controls, since biological controls are cheaper and pose less risk to humans (McLean et al., 2000).

2.10 Infiltration Devices

Infiltration has been used in the United Kingdom (UK) to deal with runoff from roots for at least a century with no widespread problems reported. It is estimated that at least 65,000 infiltration devices are installed in the UK each year (Bettes, 1996). Infiltration devices are used to drain water directly into the ground. Commonly, it may be used at source or the runoff which can be conveyed in a pipe or swale to the infiltration area. It includes soakaways, infiltration trenches and infiltration basins as well as swales, filter drains and ponds. Infiltration devices can be integrated into and form part of the landscaped areas.

Soakaways and infiltration trenches are completely located below ground, and water should not appear on the surface. Infiltration basins and swales for infiltration store water on the ground surface, but are dry except in periods of heavy rainfall. Figure 2.2 above shows the cross-section of the infiltration through traditional soakaway.

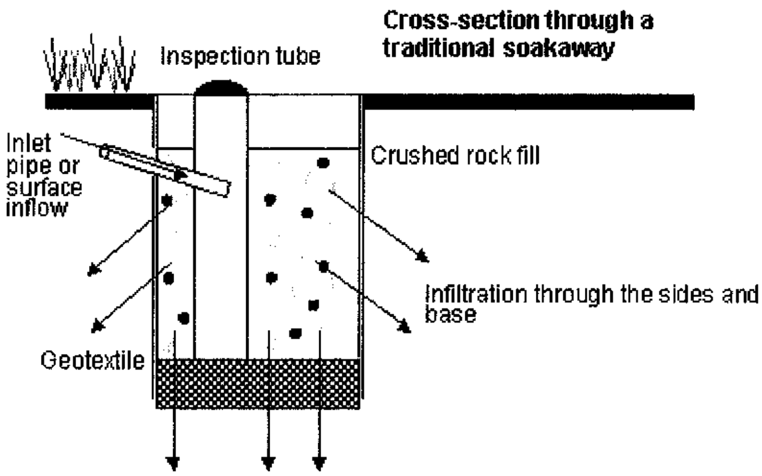

Figure 2.2 : Infiltration Cross-section through traditional soakaway (Source : CIRIA, 2007)

Wilson (2004) defined an infiltration device functions to take runoff from a development and allows it to percolate into the ground. The device has a storage volume that the runoff may be allowed to empty from the device into the ground over a period of time depends to soil condition to provide storage from runoff of stormwater. It also reduce the volume of water that has to be disposed of through sewers and at the same time provide recharge of groundwater that may maintain water levels in local watercourse.

CHAPTER 3

METHODOLOGY

3. METHODOLOGY

The methodology of this project is summarized in Figure 3.1. In order to complete this study, work plans were developed to ensure the project would be conducted according to the period of time given in both semesters.

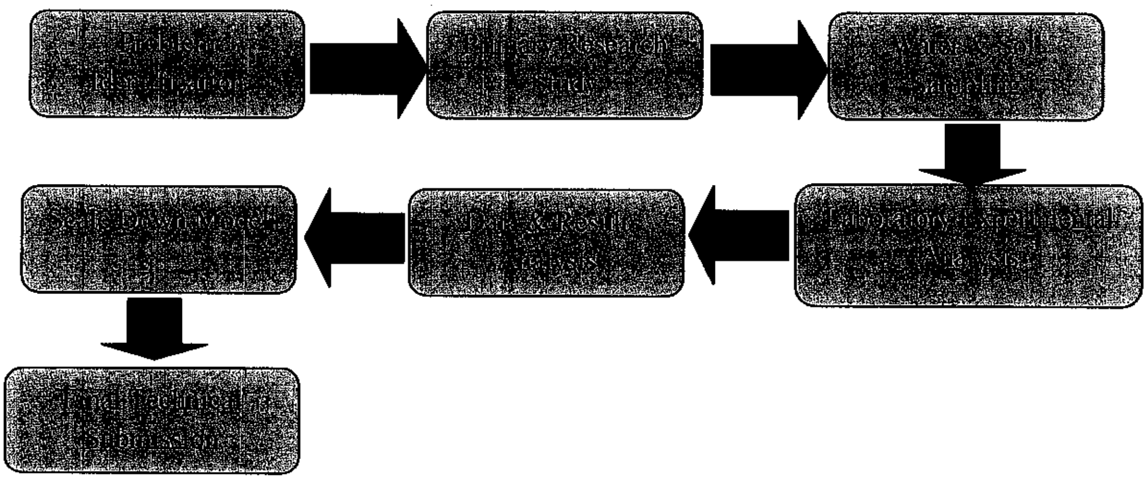

Figure 3.1 : Flow Chart of Methodology of The Project

3.1. Problem Identification

At this stage, it is very important to identify the main problem. After discussing with the supervisor, the rough idea of this project was developed. Therefore, the draft for this project have to be complete for certain a period of time.

3.2. Primary Research Study

The primary research studies were based on published materials such as *Manual Saliran Mesra Alam* (MASMA) and Construction Industry Research and Information Association (CIRIA) journals from previous researchers and Internet. To ensure the project is on track, frequent discussion with the supervisor is needed. The ideas and concept of this project need to be cleared.

3.3. Water and Soil Sampling

During this stage, water and soil sample was taken from the residential area in Seri Iskandar. The samples of water were taken directly from three different point sources which have been identified polluted. The samples were bottled and transported immediately to the laboratory. The samples may not be sufficient, so the same method needs to be repeated for test and analysis purpose in future. As for the disturbed soil sampling, the samples were taken using the steel sample tubes. The purpose is to determine the infiltration rate of the soil.

Figure 3.2: Water Sampling

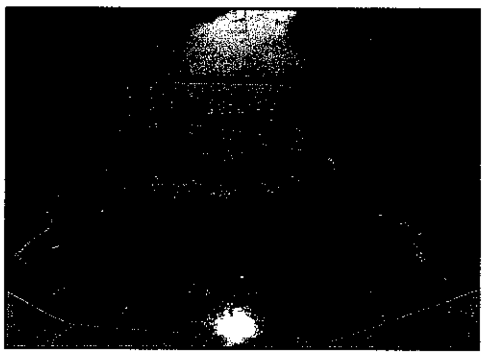

Figure 3.3 : Location of water sampling

3.4. Laboratory Experimental Analysis

The laboratory experimental analysis consists of 2 sections that are water quality analysis and soil investigation analysis. Water quality analysis was analyzed to determine the turbidity, pH, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), nitrate (NO_3), phosphorus (PO_4^{3-}). The soil samples collected from the field were analyzed to determine the particle size distribution and infiltration rate. The methods involved were Dry Sieve Analysis and Falling Head Permeameter Test.

The tests involved in Water Quality Analysis were as follows:

1. Turbidity
2. pH
3. Biochemical Oxygen Demand (BOD)
4. Chemical Oxygen Demand (COD)
5. Total Suspended Solids (TSS)
6. Nitrate (NO_3)
7. Phosphorus (PO_4^{3-})

3.4.1 Turbidity

Turbidity is a measurement of how cloudy water appears. Technically, it is a measure of how much light passes through water and it is caused by suspended solid particles that scatter light. These particles may be microscopic plankton, stirred up sediment or organic materials, eroded soil, clay, silt, sand, industrial waste, or sewage. Bottom sediment may be stirred up by such actions as waves or currents, bottom-feeding fish, people swimming, or wading, or storm runoff.

3.4.2 pH Measurement

pH is a convenient measure of acidity or alkalinity of a aqueous solution at a specific temperature. It is measured on a continuous scale from 0 to 14. pH is usually determined by electrochemical measurement in which the potential of a pH electrode immersed in the test solution is measured.

3.4.3 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is an indirect indicator of the amount of the organic matter present in waste. In simple words, BOD is the amount of oxygen used by bacteria to degrade the organic matter that present in the wastewater. When bacteria are placed in contact with organic matter, the bacteria will utilize it as a food source. The organic matter will eventually be oxidized to stable end products such as carbon dioxide and water.

3.4.4 Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. COD measurements are commonly made on samples of wastewaters or of natural waters contaminated by domestic or industrial wastes. Chemical oxygen demand is measured as a standardized laboratory assay in which a closed water sample is incubated with a strong chemical oxidant under specific conditions of temperature and for a particular period of time. A commonly used oxidant in COD assays is potassium dichromate ($K_2Cr_2O_7$) which is used in combination with boiling sulfuric acid (H_2SO_4).

3.4.5 Total Suspended Solids (TSS)

Total suspended solids is a water quality measurement usually abbreviated TSS. This parameter was at one time called non-filterable residue (NFR) a term that refers to the identical measurement: the dry-weight of particles trapped by a filter, typically of a specified pore size. However the term "non-filterable" suffered from an odd condition of usage in some circles, "filterable" meant the material retained on a filter so non-filterable would be the water and particulates that passed through the filter.

3.4.6 Ammonia Nitrogen (NH_3^-N)

Nitrogen is an element needed by all living plants and animals to build protein. In aquatic ecosystems, nitrogen is present in many forms. Nitrogen is a much more abundant nutrient than phosphorus in nature. It is most commonly found in its molecular form (N2) which makes up 79% of the air we breathe. This form however is useless for most aquatic plant growth. Blue-green algae the primary algae of algal blooms are able to use N2 and convert it into forms of nitrogen that plants can take up through their roots and use for growth: ammonia (NH3) and nitrate (NO-3).

3.4.7 Phosphorus (PO_4^{3-})

Phosphorus is usually present in natural waters as phosphate. Organic phosphate is a part of living plants and animals, their by-products, and their remains. Inorganic phosphates include the ions (H2PO-2, HPO=4, and PO-4) bonded to soil particles and phosphates present in laundry detergents. Phosphorus is an essential element for life. It is a plant nutrient needed for growth and a fundamental element in the metabolic reactions of plants and animals. Plant growth is limited by the amount of phosphorus available.

The tests involved in soil analysis were as follows:

1. Dry Sieve Analysis
2. Falling Head Permeameter Test

3.4.8 Dry Sieve Analysis

The sieve analysis or commonly known as "gradation test" is a basic essential test for all aggregate technicians. The sieve analysis is used to determine the gradation distribution of aggregate particles within a given sample in order to determine compliance with design, production control requirements, and verification specifications.

3.4.9 Falling Head Permeameter Test

Permeability is a measure of the ease in which water can flow through a soil volume. It is one of the most important geotechnical parameters. A sample with height L and cross-sectional area A is attached to a falling-head reservoir. Water is allowed to flow through the sample at a constant rate. The discharge through the sample is measured by measuring the volume of water that flows through the sample over a period of time t.

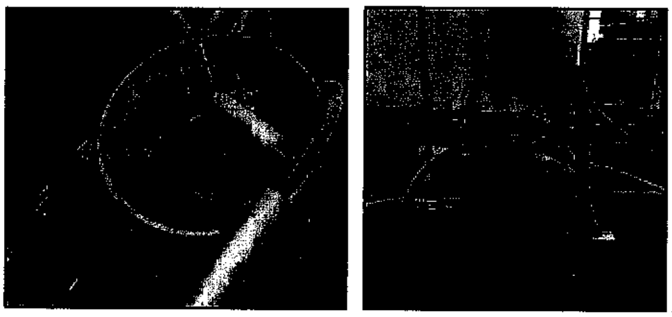

Figure 3.4: Falling Head Permeameter Test

3.5 Scale Down Model

A scale down model was constructed to evaluate the effectiveness of eco-drainage towards pollutant removal. The model used the concept of infiltration through the groundwater. The model was constructed with different layer of materials. During the construction, the materials used are polyvinyl chloride pipe (PVC) size 80mm diameter; PVC elbow size 80mm diameter as a joint and PVC end cap size 80mm. All aggregates were washed and dried to ensure the cleanliness. The soil sample from Seri Iskandar was placed on top layer in the infiltration model. Then followed by median sand size between 0.25 mm to 0.50 mm diameter, coarse sand size between 0.50 mm to 1.0 mm diameter and lastly some gravels at the bottom of the model. The soil materials were installed partially to ensure the water sample flow through it. After finished constructing the model, water sample was flowed into the infiltration device and the effluent discharge was measured from the outlet.

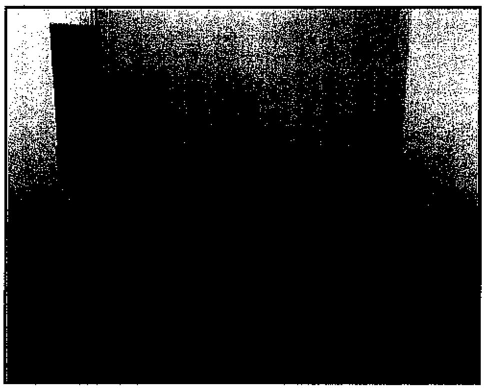

Figure 3.5: Infiltration devices

3.6 Final Technical Submission

Finally, the final stage is submitting the final technical documents such as poster and hardbound dissertation report. This documents need to be approved by supervisor before submitting to coordinator of Final Year Project 2 at Department of Civil Engineering, UTP.

CHAPTER 4

RESULT & DISCUSSION

4. ANALYSIS

All result of water quality analysis and soil analysis were presented in this section. The results were as follows:

4.1 Water Quality Analysis

4.1.1 Turbidity

Turbidity in Sri Iskandar's water sample has a mean value of 8.0 NTU (Nephelometric Turbidity Unit), which ranges from 8.0 to 8.1 NTU (Table 4.1).

Parameter	Day 1	Day 2	Day 3	Average (NTU)
Influent	8.0	8.1	8.0	8.0
Effluent	7.2	7.0	7.0	7.07

Table 4.1: Turbidity of influent and effluent

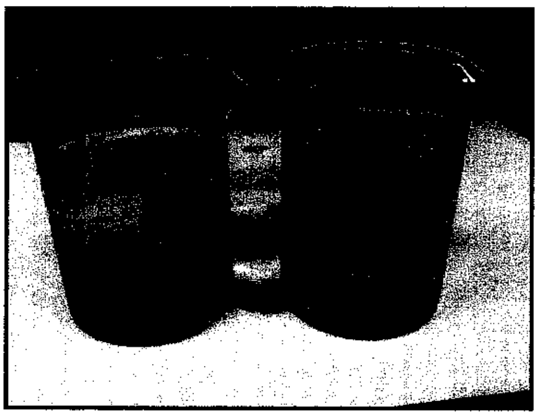

Figure 4.1: Turbidity of influent and effluent

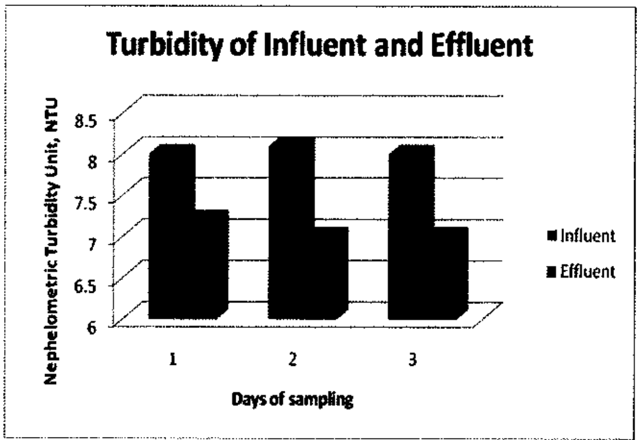

Figure 4.2: Graph shows the comparison of turbidity between influent and effluent

4.1.2 pH

The mean pH value of influent water sample was 7.24 as shown in Table 4.2.

Parameter	Day 1	Day 2	Day 3	Average
Influent	7.25	7.23	7.25	7.24
Effluent	8.2	8.25	8.21	8.22

Table 4.2: pH of influent and effluent

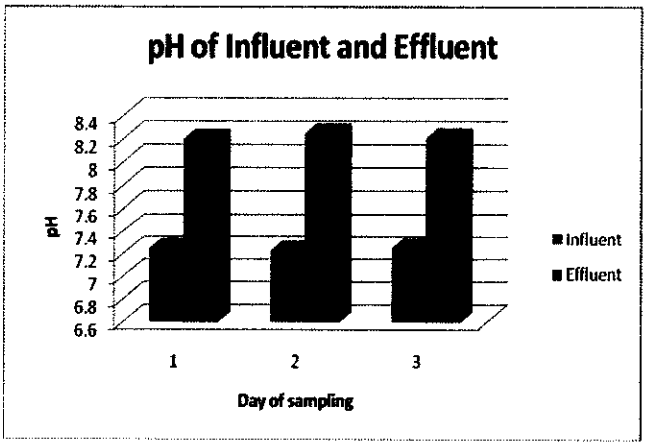

Figure 4.3 Graph shows the comparison of pH between influent and effluent

4.1.3 Total Suspended Solids (TSS)

The mean Total Suspended Solids (TSS) for influent of water sample is 192 mg/L (Table 4.3).

Parameter	No. of trial	1	2	3	Average (mg/L)
Influent	Weight of pan + filter paper (mg)	1293.4	1287.8	1287.4	192.0
	Weight of pan + dried filter paper (mg)	1311.5	1306.3	1305.1	
	TSS (mg/L)	181.0	185.0	177.0	
Effluent	Weight of pan + filter paper (mg)	1294.1	1295.2	1294.7	124.0
	Weight of pan + dried filter paper (mg)	1305.2	1308.6	1307.5	
	TSS (mg/L)	111.0	134.0	128.0	

Table 4.3: Total Suspended Solids before and after infiltration

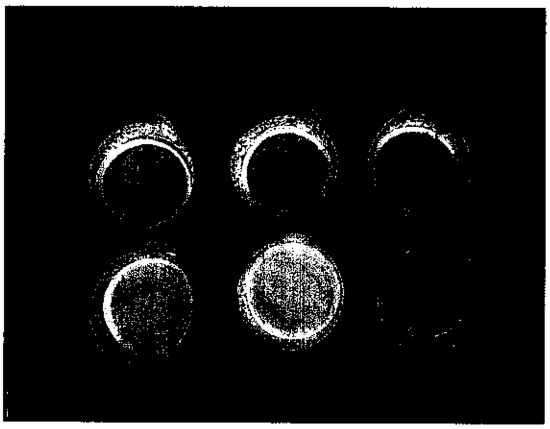

Figure 4.4: TSS for influent and effluent

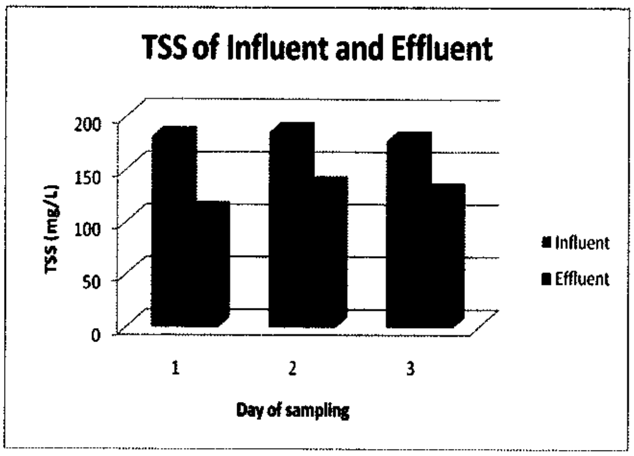

Figure 4.5: Graph shows the comparison of TSS between influent and effluent

4.1.4 Chemical Oxygen Demand (COD)

The mean chemical oxygen demand (COD) for influent of water sample is 53 mg/L COD (Table 4.4).

Parameter	Day 1	Day 2	Day 3	Average (mg/L COD)
Influent	86	88	88	87.3
Effluent	54	53	52	53.0

Table 4.4: COD value of influent and effluent

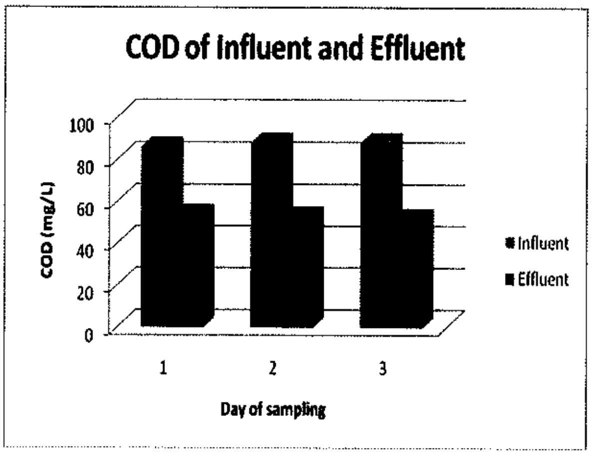

Figure 4.6: Graph shows the comparison of COD between influent and effluent

4.1.5 Biochemical Oxygen Demand (BOD)

The mean biochemical oxygen demand after 5 days (BOD_5) for influent of water sample is 192 mg/L BOD (Table 4.5).

Parameter	Day 1	Day 2	Day 3	Average (mg/L BOD)
Influent	64	63	63	63.3
Effluent	48	46	48	47.3

Table 4.5: BOD_5 value of influent and effluent

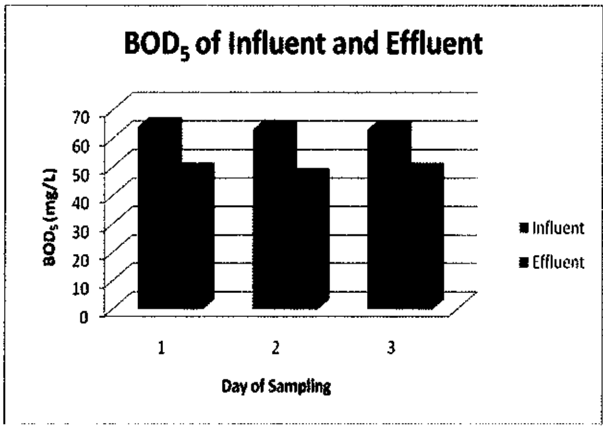

Figure 4.7: Graph shows the comparison of BOD_5 between influent and effluent

4.1.6 Dissolved Oxygen (DO)

The mean dissolved oxygen for influent of water sample is 3.21 mg/L (Table 4.6).

Parameter	Day 1	Day 2	Day 3	Average (mg/L)
Influent	3.2	3.22	3.21	3.21
Effluent	4.0	4.3	4.3	4.20

Table 4.6: DO value of influent and effluent

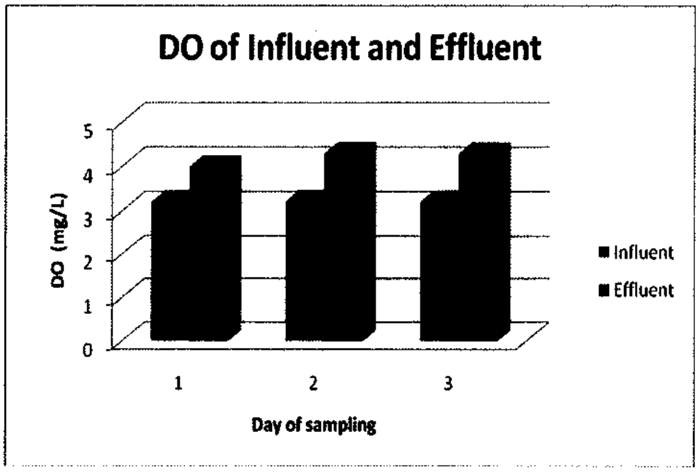

Figure 4.8: Graph shows the comparison of DO between influent and effluent

4.1.7 Ammonia Nitrogen

The mean ammonia nitrogen content for influent of water sample is 0.31 mg/L NH_3-N (Table 4.7).

Parameter	Day 1	Day 2	Day 3	Average (mg/L NH_3-N)
Influent	0.32	0.31	0.31	0.31
Effluent	0.28	0.26	0.29	0.28

Table 4.7: Ammonia nitrogen value of influent and effluent

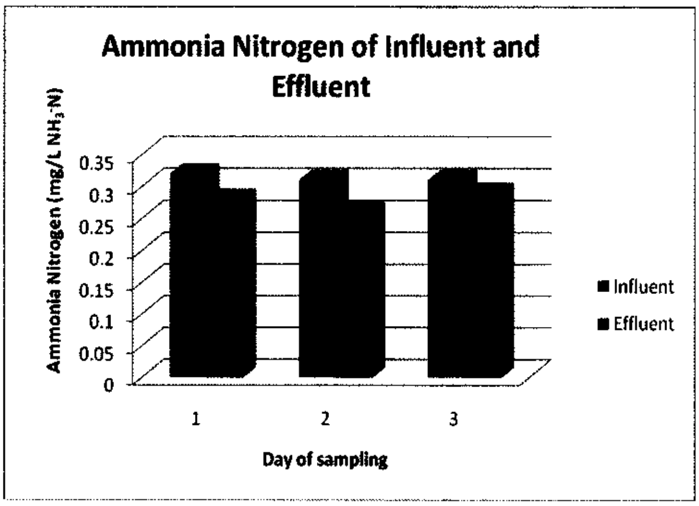

Figure 4.9: Graph shows the comparison of Ammonia Nitrogen between influent and effluent

4.1.8 Total Phosphorus

The mean content of total phosphorus for influent of water sample is 0.71 mg/L PO_4^{3-} (Table 4.8).

Parameter	Day 1	Day 2	Day 3	Average (mg/L PO_4^{3-})
Influent	0.78	0.65	0.71	0.71
Effluent	0.66	0.58	0.67	0.64

Table 4.8: Total Phosphorus value of influent and effluent

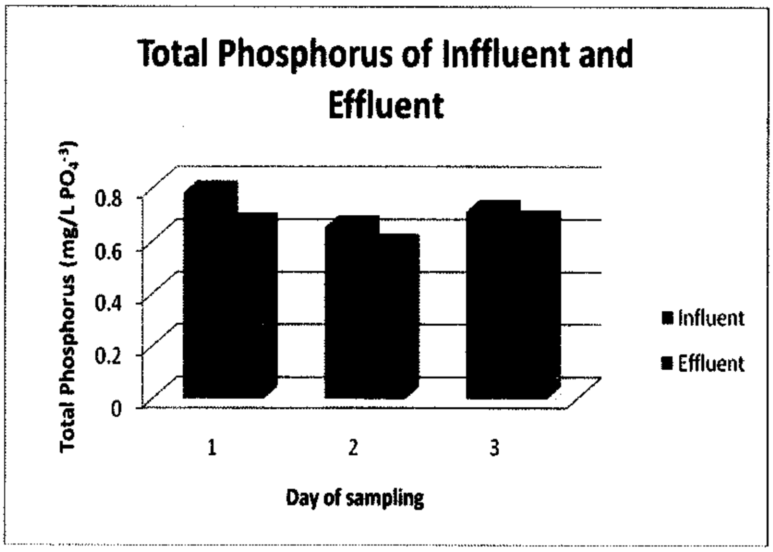

Figure 4.10: Graph shows the comparison of Total Phosphorus between influent and effluent

The results were compared with the Standard Class IIA as shown in Table 4.9

No	Parameter	Influent	Effluent	Standard Class IIA*	Percentage Removal (%)
1	pH	7.24	8.22	6-9	-13.54
2	Turbidity (NTU)	8.0	7.07	50	11.63
3	DO (mg/L)	3.21	4.20	5-7	-30.84
4	TSS (mg/L)	192	124	50	35.42
5	COD (mg/L)	87.3	53.0	25	39.29
6	BOD_5 (mg/L)	63.3	47.3	3	25.16
7	Ammonia Nitrogen (mg/L NH_3-N)	0.31	0.28	0.3	9.68
8	Total Phosphorus (mg/L PO_4^{3-})	0.71	0.64	-	9.86

Table 4.9: Comparison between influent, effluent and Standard Class IIA

*Class IIA is for Water Supply II – conventional treatment required
Source : Table 2.3 Interim National Water Quality Standards for Malaysia

4.2 Particles Size Distribution

Table 4.10 shows the particle size distribution data for site area of Seri Iskandar. The data was taken from the sieve analysis method. Figure 4.11 shows the percentage of particle based on the semi-log graph particle size distribution.

Sieve Size (mm)	Weight Retained (g)	Percentage Retained (%)	Cumulative Percentage Retained (%)	Percentage Passing (%)
2.0	100	18.18	18.18	81.82
1.18	60	10.91	29.09	70.91
0.6	65	11.82	40.91	59.09
0.425	50	9.10	50.01	49.99
0.30	55	10.00	60.01	39.99
0.212	70	12.73	72.74	27.26
0.15	50	9.10	81.84	18.16
0.063	60	10.91	92.75	7.25
Pan	40	7.25	100.00	0.00
Total	550			

Table 4.10: Site area of Seri Iskandar particle size distribution data

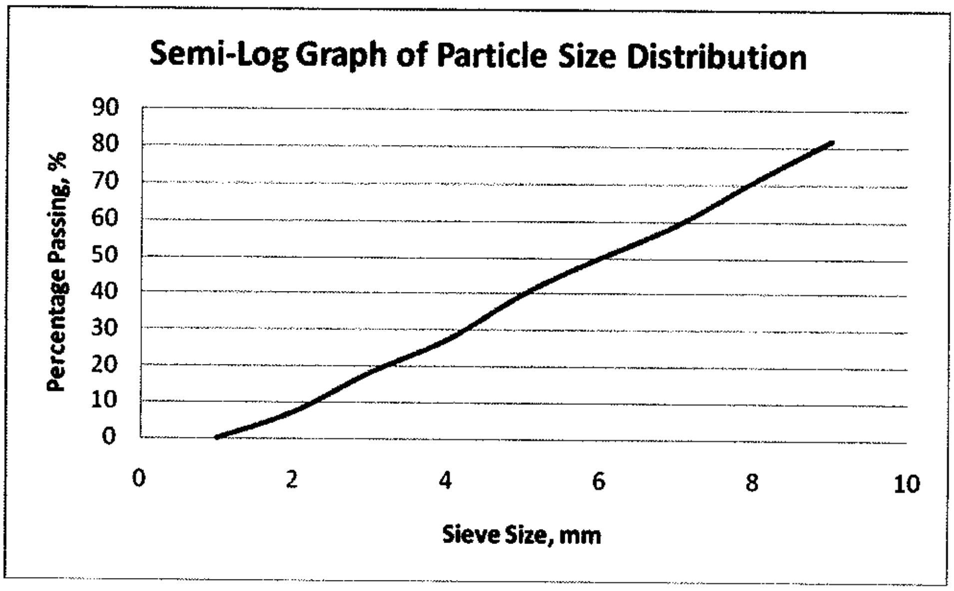

Figure 4.11: Semi-log graph of particle size distribution

4.3 Infiltration Rate, f_c

The infiltration rate is the speed at which water enters into the soil. Infiltration rate of site area at Sri Iskandar soil was determined from Falling Head Permeameter Test conducted in the Geotechnical laboratory. The soil sample was stored in vertical cylinder. Then the cylinder contained the sample was kept in container filled with water and the soil sample was saturated by allowing the water to flow continuously through the sample from the stand pipe (fully saturated condition).

Sample diameter (mm)	100
Sample Length (mm)	130
Stand-pipe Diameter (mm)	5.4
Initial Head of Water (mm)	500
Final Head of Water (mm)	100
Measured height (mm)	400
Time (s)	300
Time taken	300s = 0.083 hour

Table 4.11: Falling Head Test data

Area of stand-pipe (mm^2)	22.90
Area of sample (mm^2)	7853.98
Coefficient of permeability, k or Design infiltration rate, f_d	7.35 mm/hr
Minimum f_c or k	13 mm/hr
f_d	$0.5f_c$
Infiltration Rate, f_c	**14.70mm/hr**

Table 4.12: Calculation of Infiltration Rate

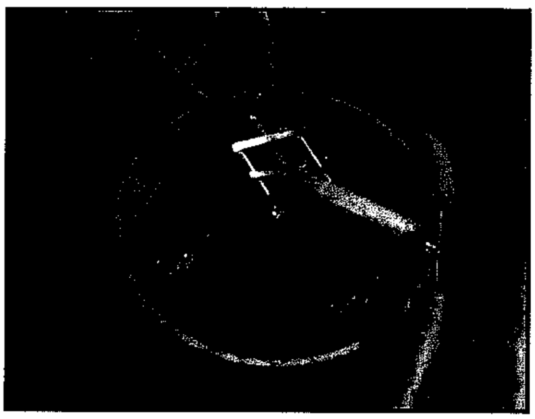

Figure 4.12: Falling Head Permeameter Test

4.4 Construction Model of Infiltration Device

The infiltration model was constructed to represent the concept of the infiltration process. The model includes the influent pipe connected to existing drain and effluent to groundwater. The shape of the model is L-shape. The purpose of the model was to compare the quality between the influent and effluent after the treatment of infiltration. The materials used to construct this model are two pipes of Polyvinyl Chloride (PVC), one PVC elbow and one PVC end pipe. The elbow is jointed with two pipes and constructed into L-shape. The pipe is then filled with different layers of coarse gravels, coarse sand and medium sand. The water sample is then poured through the infiltration model and the effluent was tested in the environmental laboratory.

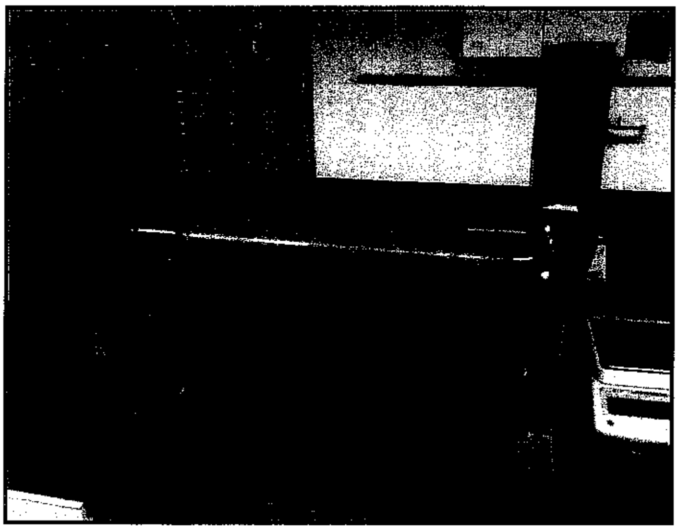

Figure 4.13 Model of Infiltration Device

4.5 Discussion

4.5.1 Turbidity and Total Suspended Solid

Turbidity is a measure of cloudiness in the water. From the water quality analysis which has conducted, the turbidity of water sample in Sri Iskandar existing drain is still in moderate condition. Generally, the site area was surrounded with residential area and shophouses such as restaurant, workshop and pet shop. The sewerage water contained oil grease and detergent discharged from the restaurant. This however contributes to high suspended solid (TSS) to the existing drain. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Based on the Malaysia Interim Water Quality Standard for Class IIA, standard value for turbidity and TSS are 50 NTU and 50 mg/L. From the collected water sample, it shows that the value of both parameters exceeded the standard value. After the treatment using infiltration device the value of turbidity was reduced from 8.0 to 7.07 NTU and for TSS the value was decreased from 192 to 124 mg/L.

4.5.2 COD and BOD

COD was conducted to measure the oxygen equivalent consumed by organic matter in the sample during strong chemical oxidation. The result shows that the COD value was improved from 87.3 mg/L COD to 53 mg/L COD. The COD results were mostly above the standard limit. BOD was conducted to determine the uptake rate of dissolved oxygen by the biological organisms in a body of water. From the result, it shows that the water sample contained 63.3 mg/L BOD_5 and the value reduced to 47.3 mg/L BOD_5. The flow in the existing drain was in statically condition where the water was not flowing because the drain was not managed well.

4.5.3 Total Phosphorus and Ammonia Nitrogen

Phosphorus was a nutrient used by organisms for growth. It occurs in natural water and wastewater bound to oxygen to form phosphates. Phosphates come from a variety of sources including agricultural fertilizers, domestic wastewater, detergents, industrial process wastes and geological formations. Total Phosphorus contained in water sample was in range 0.71 to 0.64 mg/L PO_4^{3-}. The discharge of wastewater containing phosphorus can cause algae growth in quantities sufficient to cause taste and odor problems in drinking water supplies. Dead and decaying algae cause oxygen depletion problems that can kill fish and other aquatic organisms in the existing drain. Raw wastewater nitrogen is normally present in the organic nitrogen and ammonia forms, with small quantities of the nitrite and nitrate forms. Ammonia Nitrogen contained in water sample was in range 0.31 to 0.28 mg/L NH_3-N. After the water passed by the infiltration device, the value was removed for 9.68%.

4.5.4 Falling Head Permeameter

Based on the design criteria, falling head permeameter was conducted to determine the coefficient of permeability of the given soil sample. According to the design criteria for design infiltration rate (f_d), will be equal to one-half (factor of safety) the infiltration rate (f_c) found from the experiment with minimum f_c of 13 mm/hr. ($f_d = 0.5f_c$). From the result data indicates that the value of f_c of soil sample taken from Sri Iskandar was 14.70 mm/hr. It shows that the k value exceeds to minimum f_c and the soil is suitable for infiltration treatment device. To calculate the k or f_c value:

$$k \text{ or } f_c = 2.303 \frac{aL}{At} \log_{10} \frac{h1}{h2}$$

a = *cross sectional area of standpipe*

A = *cross sectional area of soil specimen*

t = *time taken for total head reduce from h1 to h2*

h1 = *initial height of water*

h2 = *final height of water*

CHAPTER 5

CONCLUSION & RECOMMENDATION

Based on the studies it can be concluded that the infiltration device was suitable to be implement at the site area of Sri Iskandar. The purpose of the infiltration device was to take off runoff from development and allows it to percolate into the ground. It reduced the volume of water that has to be disposed of through sewers and then recharge of groundwater which able to maintain water level in local watercourses.

Results showed that there is an improvement in the water quality elements such as turbidity, pH value, COD, BOD_5, DO, Ammonia Nitrogen and Total Phosphorus. For the turbidity test, the percentage of removal was 11.63%, COD reduce to 39.29%, BOD reduce to 25.16%, Ammonia Nitrogen reduce to 9.68% and Total Phosphorus reduce to 9.86%.

As mentioned before, the main objective of this project is to develop the drainage system to support an aquatic life that promotes balance eco-system. The purpose of eco-drainage is to recharge the stormwater to groundwater, to prevent the flooding when it rains heavily and lastly to provide a balance eco-system for aquatic life.

In conclusion, this project is still under development phase where there will be some requirements and aspects that need to be addressed of. Hopefully, the objective of this project could be achieved by analyzing the results of experiment analysis in the future soon.

CHAPTER 6

ECONOMIC BENEFITS

Based on the research has been done for this project, the cost spent to complete the final year project was stated below:

No.	Item	Unit Price	Quantity	Total Price
1.	3" PVC Pipe	RM 1.20	4.5 ft	RM 5.40
2.	3" PVC Elbow	RM 3.00	1	RM 3.00
3.	3" PVC End Cap	RM 4.00	1	RM 4.00
4.	16mm PE Socket	RM 0. 50	1	RM 0.50
5.	16mm Big Rubber Grommet	RM 2.50	1	RM 2.50
	Total per unit of device			**RM 15.40**

Table 6.1: The total cost per unit of infiltration device

This total per unit device was calculated for one unit device installed in the site area. Assume if the devices were installed about 10 unit devices at the site, the total up of the cost was RM 154.00. But the number of the devices to be installed depends on the wide area of the site at Sri Iskandar.

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