Appraisal of Drainage System in Term of Water Stagnation in Urban Environment

By

Julina Binti Samsu

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

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Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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Approved by,

(Assoc. Prof. Dr. Nasiman Sapari)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK DARUL RIDZUAN

JULY 2006

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.

(JULINA BINTI SAMSU)

ABSTRACT

This project title is 'Appraisal of drainage system in term of water stagnation in urban environment'. The study area chosen for assessment is Manjung which focus on Taman Megah Tiga in Sitiawan and Taman Mas in Kampung Koh and also Universiti Teknologi Petronas, UTP. The area is selected with the recommendation from Personnel from Jabatan Kesihatan Perak Tengah, Mr. Mohan since it recorded a high number of dengue cases in 2004 which is 100 cases for Sitiawan and 97 cases for Kampung Koh. Due to the high cases of dengue fever in the area, Jabatan Kesihatan Daerah Manjung has taken preventive measure by using 'Abete' to kill mosquito larvae.

In this project, an assessment of the existing drainage system for the study area has been done and testing has been done on the quality of water sample taken from different sumps that have water stagnation problem. For this project, only 7 samples were collected and tested for BOD, COD, pH, turbidity and total suspended solids (TSS). The value for BOD range from 17 mg/L to 55 mg/L while for COD, the value range from 9 mg/L to 128 mg/L. The total suspended solids of the samples range from 0.2 mg/L to 0.5 mg/L. The water samples were quite neutral since most of the pH values were more or less equal to 7. Ovitrap research was also done for UTP to determine the ovitrap index. The result shows that the ovitrap index is 40%. The result shows that UTP is susceptible to Dengue outbreak and serious measures have to be done to reduce the breeding ground of mosquito.

In the literature review and theory section, result from previous research conducted in India and Thaland are presented. In India, there has been a program to control Malaria by using larvivorous fish such as Gambusia. The application of the larvivorous fish shows a positive result where after the application, breeding of mosquito is reduced rapidly and at some places, it is reduced to 0%.

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First of all, Alhamdulillah and thanks to Allah S.W.T, The Most Gracious, The Most Merciful because of His blessing, after facing a lot of obstacle, I successfully completed my final year project. I would like to take this opportunity to express my gratitude to the individuals and peoples who had helped a lot to accomplish this final year project.

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CHAPTER 1
INTRODUCTION

1.1 Problem statement

Structures in drainage system such as sump and manhole may promote water stagnation. Thus, they become breeding grounds for mosquito to lay eggs. Consequently, it results in more mosquito populations especially in urban environment where more engineering structures can be found with water stagnation problem. Managing stormwater has traditionally involved activities related to the control of quantity and quality of stormwater runoff. However, recent concerns about disease vectors that might be associated with structural stormwater best management practices (BMPs) have caused many stormwater professionals begin to consider the potential public health impacts of certain structural BMPs. Those involved in BMP design, implementation, operation, and regulations agree that the responsibilities of stormwater management go beyond simple compliance with urban runoff regulations. The challenge now has become an issue of maintaining compliance with state and federal stormwater regulations while simultaneously minimizing the potential impacts to public health.

1.2 Objectives

- To identify the existing engineering structures that may retain water
- To study the common functionality problems faced by the engineering structures
- To propose modification on the existing design that can avoid water stagnation in order to prevent breeding of mosquitoes especially Aedes
- To propose bio control using larvivirous fish and water bugs in the structure where modification in the design is not possible or not economical

1.3 Background

Dengue and dengue heamorrhagic fever are a vector bourne disease which is transferred by Aedes mosquitoes. The vector for dengue fever is the female aedes mosquitoes. The dengue haemorrhaegic fever is one of the main factors of child death in Malaysia. Dengue fever is actually caused by four types of viruses that are transferred to human being from aedes mosquitoes. The four types of dengue viruses are flavivirus DEN-1, DEN-2, DEN-3 and DEN-4. All aedes mosquitoes are vector but the main vector is aedes
'Aegypti'. For urban areas, the main vector is aedes 'Albopictus' (Abdullah.K, 2002, p.7). Figure 1.1 and 1.2 below shows a photo of Aedes Aegypti and Aedes Albopictus. It is a little bit hard to differentiate the two types of Aedes mosquito. Generally, the size of Aedes Albopictus is longer and the colour is darker than Aedes Aegypti.

Figure 1.1: Aedes Aegypti

Figure 1.2: Aedes Albopictus

In Malaysia, the number of dengue fever and dengue haemorrhagic fever cases is increasing at alarming rate from year to year. From the data produced by the Ministry of Health in 1998, the rate for dengue fever and dengue haemorrhagic fever are 118.3 and 5.1 and the death rate are 0.22 and 0.23 for every 100000 residents.

For the past decades, not only in Malaysia, dengue incidents have increase globally. Recently, dengue has been an epidemic in more than 100 countries including African region, America, Mediterranean region, South East Asia and West Pacific (Khairul Anuar S, 2002, p.2). The number increases to four times from 1995 with at least 41 countries are involved. For this project, Taman Megah Tiga and Taman Mas are selected as study area since it recorded a high number of dengue cases in Manjung. The cases have decreased lately after Jabatan Kesihatan Manjung took preventive measures by using 'Abete" in septic tanks and also drains. Table 1.1 below shows the number of dengue cases in Manjung district for the year 2004. The GIS map of the dengue cases in Manjung district and the layout plan of Taman Mas and Taman Megah Tiga can be found in the appendix.

Table 1.1: Number of Dengue cases in Manjung district for the year 2004

Area	No. of cases
Seri Manjung	63
TLDM	89
Lumut	7
Pulau Pangkor	21
Pantai Remis	8
Beruas	10
Ayer Tawar	150
KB Ayer Tawar	99
Simpang Lima	32
Pekan Gurney	74
Sitiawan	100
Kampung Koh	97

Source: Pejabat Kesihatan Perak Tengah

Over 2500 species of mosquitoes have been described from around the world. These insects occupy practically every conceivable ecological niche, which is reflected by tremendous variations in the biology and ecology of individual genera or species. One unifying feature of this group is that they all have obligate aquatic larvae. Aquatic habitats are chosen and utilized by different species based on a wide variety of factors including nutritional requirements, egg-laying behavior, and climate; however, any source of standing water will usually provide suitable habitat for at least some mosquito species. Unfortunately, opportunistic mosquito species likely to inhabit temporary pools of standing water, especially in disturbed habitats, are those that are also important vectors of human and animal diseases. It is because of this that the design of stormwater BMP structures becomes crucial and they must be engineered to prevent the retention of water for no more than 3 days (72 hours). This is because most eggs hatch into larvae within 48 hours and matures to adult in 4 to 7 days (W. Patrick McCafferty, 1983). It is also important to note that mosquito larvae can develop in extremely shallow water and since they breathe atmospheric air, may even survive short periods of time without water as long as the environment remains moist (Metzger, 2003, p.3). The lifecycle of a mosquito is further explained below.

The mosquito goes through four separate and distinct stages of its life cycle and they are as follows: Egg, Larva, pupa, and adult as shown in figure 1.3 below. Each of these stages can be easily recognized by their special appearance. There are four common groups of mosquitoes living in the Bay Area. They are *Aedes, Anopheles, Culex,* and *Culiseta.*

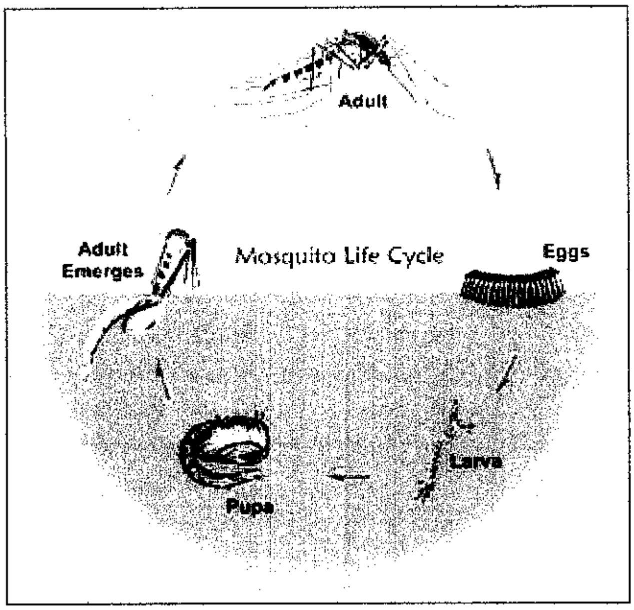

Figure 1.3: Mosquito Life Cycle

Eggs are laid one at a time and they float on the surface of the water. In the case of *Culex* and *Culiseta* species, the eggs are stuck together in rafts of a hundred or more eggs. *Anopheles* and *Aedes* species do not make egg rafts but lay their eggs separately. *Culex, Culiseta,* and *Anopheles* lay their eggs on water while *Aedes* lay their eggs on damp soil that will be flooded by water. Most eggs hatch into larvae within 48 hours (W. Patrick McCafferty, 1983).

The larva (larvae - plural) lives in the water and come to the surface to breathe. They shed their skin four times growing larger after each molting. Most larvae have siphon tubes for breathing and hang from the water surface. *Anopheles* larvae do not have a siphon and they lay parallel to the water surface. The larva feed on micro-organisms and organic matter in the water. On the fourth molt the larva changes into a pupa. The pupa stage is a resting, non-feeding stage. This is the time the mosquito turns into an adult. It takes about two days before the adult is fully developed. When development is complete, the pupa skin splits and the mosquito emerges as an adult.

The newly emerged adult rests on the surface of the water for a short time to allow itself to dry and all its parts to harden. Also, the wings have to spread out and dry properly before it can fly. The egg, larvae and pupae stages depend on temperature and species characteristics as to how long it takes for development. For instance, *Culex tarsalis* might go through its life cycle in 14 days at 70 F and take only 10 days at 80 F (W. Patrick McCafferty, 1983). Also, some species have naturally adapted to go through their entire life cycle in as little as four days or as long as one month.

There are two distinct groups of mosquitoes that utilize habitats created by stormwater management structures. The permanent water species lay their eggs directly on the water surface or on the leaves of aquatic plants. Eggs of species such as *Anopheles*, *Coquillettidia*, *Culiseta*, *Culex*, *Mansonia*, and *Uranotaenia* do not require external stimuli and hatch within a few days. The floodwater species deposit eggs on moist soil around aquatic systems and the eggs hatch when submerged by rising water levels. These 'floodwater' mosquitoes include the genera *Aedes* and *Psorophora* (Chanda, D.A., J.K Shisler, 1980, p.7). These behavioral differences have major impacts on the species that may utilize different structural BMP designs. BMPs engineered with minimal or infrequent water level fluctuations (e.g. settling basin) seldom support floodwater mosquitoes. In contrast, permanent or semi-permanent aquatic systems, particularly those containing emergent vegetation and nutrient-rich water, can provide suitable habitat for both groups of mosquitoes.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Literature Review

Dengue cases have been on the rise and could become a serious public health problem if the epidemic is not managed properly. It seems there is a correlation between the dengue's case increase and the urbanization activities, where more than 80% of the cases are reported in the urban area. The design of existing drainage systems is primarily to meet the engineering design codes. Unfortunately, the ecological factors are not considered in the design. Therefore, it is not impossible for mosquitoes to breed in this kind of environment, where there is no biological control in the system. So, those structures may contribute to the problems of dengue fever in urban areas.

A few studies have been done especially in western countries such as the USA and United Kingdom to determine the distribution of mosquitoes in storm drain system. Tianyun Su, James P. Webb and Richard P. Meyer (2003) have conducted investigations on spatial and temporal distribution of mosquitoes in the drainage systems (manhole, catch basin and drain) during November 1999 to October 2001. Immature mosquitoes were sampled by dipper or dipping net and adult mosquitoes by non– attractive CDC traps in manhole chambers, catch basins and a large drain. *Culex quinquefasciatus* are present at all 15 structures that were investigated, in 4 cities of Orange County, US as the predominant species (> 99.9%). Larvae and pupae were present from April to October, peaking from May to September. The population density of adults was the lowest in February with 2 peaks of abundance occurring from May to July and from September to October. Manhole chambers and catch basins harbored more mosquitoes than did the large drain. The general trend discussed above is for Orange County in USA. It may not apply to Malaysia as the climate is different.

In India, a case study has been done in developing lavivorous fish network for mosquito control in urban areas. The development of larvivorous fish network in

Ahmedabad was carried out in a phased manner as part of a project on demonstration of integrated control of malaria and dengue vectors in the city. During the preparatory phase (June 1998 - May 1999) a survey of the potential mosquito breeding habitats and aquatic habitats suitable for the development of larvivorous fish hatcheries was carried out in the city. There were large numbers of domestic and peri-domestic mosquito breeding habitats eg., open cemented overhead and ground level tanks, underground tanks, mill tanks, water hydrants, fountains, cisterns (earthen barrels) sluice valve chambers, ornamental tanks in gardens, curing tanks and lift pits at construction sites, wells, ponds/pools, industrial waste water pools, troughs for storing drinking water for cattle, open drains, ditches/small pools and water logged low lying areas ideally suited for the breeding of malaria and dengue vectors and nuisance mosquitoes (Prasad, H., Prasad, R.N. and Haq, 1993, p.25). These habitats were found suitable for the introduction of larvivorous fishes. Some of the sites were selected for the development of larvivorous fish hatcheries to ensure the availability of larvivorous fishes in the entire city.

During the monitoring phase impact of introduction of larvivorous fishes on mosquito breeding was assessed. Survival and stock of the fishes were periodically monitored and whenever required more fishes are added.

Impact of larvivorous fish on mosquito breeding was assessed by monitoring the larval density before and after the application. The most common mosquito breeding places such as under-ground cement tanks, ground level tanks, fountains, elevator chambers (lift wells), wells, mill hydrant tanks, cattle troughs and ponds were exclusively monitored. In general a sharp reduction in the larval densities was observed in most of the habitats during the post application period.

The percentage of breeding positive underground tanks was brought down to 15.8 from 94.7 prior to the fish application. Proportion of ground level tanks showing mosquito breeding was reduced from 81.3 to 18.7% after fish application. Mosquito breeding was recorded at 25% and 33% in fountains and elevator chambers (lift pits) during the post application period compared to 85.7 and 100% respectively before the fish application (S. Haq, VK Kohli, 2003, p.5). Refer to table 2.1 below.

Table 2.1: Impact of lavivorous fishes on mosquito breeding in different habitat

Months	Underground tanks		Ground level tanks		Fountains		Elevator chambers		Wells		Hydrants		Ponds		Cattle troughs	
	No.	% positive	No.	% positive	No.	% positive	No.	% positive	No.	% positive	No.	% positive	No.	% positive	No.	% positive
Before fish introduction																
June-99	19	94.7	16	81.3	8	55.7	6	100	9	100	2	100	3	100	2	50.0
After fish introduction																
1999																
July	19	15.8	16	6.3	8	12.5	6	16.7	9	22.2	3	33.3	3	33.3	2	0
August	19	10.5	17	11.8	7	14.3	6	33.3	9	22.2	3	0	3	0	2	0
September	19	5.3	17	5.9	8	25.0	5	60.0	9	11.1	3	33.3	3	66.7	2	0
October	19	5.3	17	5.9	8	12.5	4	25	9	11.1	3	66.7	3	33.3	2	0
November	17	11.8	17	11.8	8	12.5	4	25	9	11.1	3	33.3	3	0	2	0
December	21	9.5	17	5.9	8	25.0	5	20	9	11.1	3	0	3	0	2	0
2000																
January	21	0	17	5.9	8	0	5	20	9	11.1	2	0	3	0	2	0
February	21	0	17	5.9	8	12.5	6	33.3	9	22.2	2	0	3	0	1	0
March	23	13.4	16	15.1	8	0	6	0	9	0	2	0	3	0	2	50.0
April	22	13.6	16	0	8	25.0	5	0	9	0	2	0	3	0	2	0
May	23	0	16	0	8	0	5	20.0	8	0	1	0	3	0	2	0
June	23	13.4	16	15.7	8	25.0	5	0	7	0	1	0	3	0	2	0

Source: Dr. S. Haq, VK Kohli, 2003, p.5

Dengue infection, one of the most important mosquito-borne viral diseases of humans, is now a significant problem in several tropical countries such as Malaysia, Thailand Indonesia and Singapore (Gratz 1993). Therefore, the correlation between rainfall and Dengue prevalence is of interest recently as it provides useful information for prevention and control of diseases (Udomsakdi, 1973). The graph in figure 2.1 below shows the correlation of average rainfall and dengue prevalence in 22 provinces of central region in Thailand from a study conducted by Viroj Wiwanitkit, 2004.

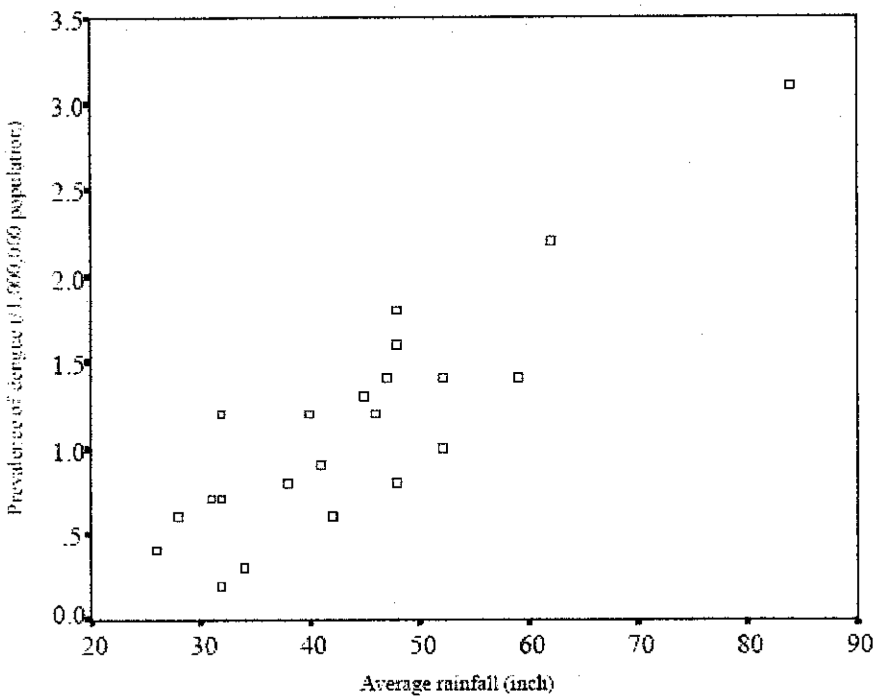

Figure 2.1: Correlation of average rainfall and dengue prevalence

This study confirmed the effect of rainfall on the prevalence of dengue where higher prevalence of dengue was recorded at higher average rainfall. Indeed, there was a recent report on seasonal variation in dengue prevalence in Thailand, which indicated the peak prevalence in the rainy season when the rainfall is very high (Gratz 1993). According to this study, the prevalence of dengue infection in central region of Thailand may depend on rainfall. Indeed, the high rainfall is reported for its strong correlation with the spreading of the vector mosquitoes (Indaratna et al 1998). Therefore, the surveillance and control of mosquitoes in the studied area during the period with high rainfall is recommended. However, it should take into account other confounding factors that affect the transmission of dengue, including other seasonal factors like ambient temperature and humidity, before concluding that the increased prevalence is a result of rainfall alone.

2.2 Theory

Sump or sometimes called catch basin plays the major role in providing breeding ground for mosquito in open drain system. Therefore, the theory in designing the structure needs to be review in order to improve the design. Deep sump catch basins are modified versions of the inlet structures typically installed in a piped storm water conveyance system. Deep sumps provide capacity for sediment accumulation. Deep sump catch basins are most effective if placed "off-line" – that is, if they do not have inlet pipes. Flow-through basins are more susceptible to sediment re-suspension. Deep sump catch basins can serve as pre-treatment for other BMPs. For new or redevelopment projects, catch basins are an option that should be evaluated on a case-by-case basis to replace drop inlets. Where feasible, deep sumps should be incorporated into drainage systems (for both catch basins and drop inlets), employing off-line operation, to the maximum extent practicable. Potential site constraints include hydraulic grade line, bedrock, and high water tables. Practical experience has demonstrated that catch basin hoods are not effective in highway settings, although they work well in many other settings (Brown, 2002, p.35). Hoods are prone to damage and displacement during cleaning and are not recommended for highway use. However, hoods may provide benefits along high-litter areas, as well as in parking lots and service areas (e.g., maintenance facilities, park-and-ride lots, and rest areas) (Richards, AG, 2006, p.21).

When designing sump or any other structures in drainage system, four things that are stated below need to be consider eliminating breeding ground for mosquito (Messer, 2001, p.9):

- Completely seal structures that retain water permanently or longer than 72 hours to prevent entry of adult mosquitoes. Adult female mosquitoes may penetrate openings as small as 1/16 inch (2 mm) to gain access to water for egg laying. Screening can exclude mosquitoes, but it is subject to damage and is not a method of choice.

- If using covers, they should be tight fitting with maximum allowable gaps or holes of 1/16 inch (2 mm) to exclude entry of adult mosquitoes. The use of gaskets can provide a much more effective barrier when used properly.
- If the sump, vault, or basin is sealed against mosquitoes, with the exception of the inlet and outlet, submerge the inlet and outlet completely to reduce the available surface area of water for mosquito egg-laying (female mosquitoes can fly through pipes). Alternatively, creative use of flapper or pinch valves, collapsible tubes (Dr PK Mittal, 2000), and "brush curtains" might be effective for mosquito exclusion in certain designs.
- Design structures with the appropriate pumping, piping, valves, or other necessary equipment to allow for easy dewatering of the unit if necessary.

Apart from the four things stated above by "Messer, 2001, p. 9", other structures can be used in order to minimize the likelihood of water stagnation and thus minimize breeding of mosquito such as soakaway pit, infiltration trench, infiltration basin, vegetated swales and etc. In this study, soakaway pit is designed to convey water that is accumulated in a sluice valve chamber.

Soakaway pits are small, excavated pits, backfilled with aggregate, used to infiltrate "good quality" stormwater runoff, such as uncontaminated roof runoff. Rooftop runoff is discharged to the soakaway pit through the roof leader, which extends directly into a stone-filled reservoir. The use of soakaway pits is limited by a number of site constraints, including soil type, contributing drainage area, depth to bedrock, and depth to groundwater. Therefore, prior to installing a soakaway pit system in an area, soil investigation need to be done to determine the suitability of the area for infiltration system. Soakaways are similar to trenches in operation but have a larger plan area, being typically rectangular and of shallower depth (Figure 2.2). Infiltration soakaways can be applied across a range of scales from residential allotments through to open space or parklands.

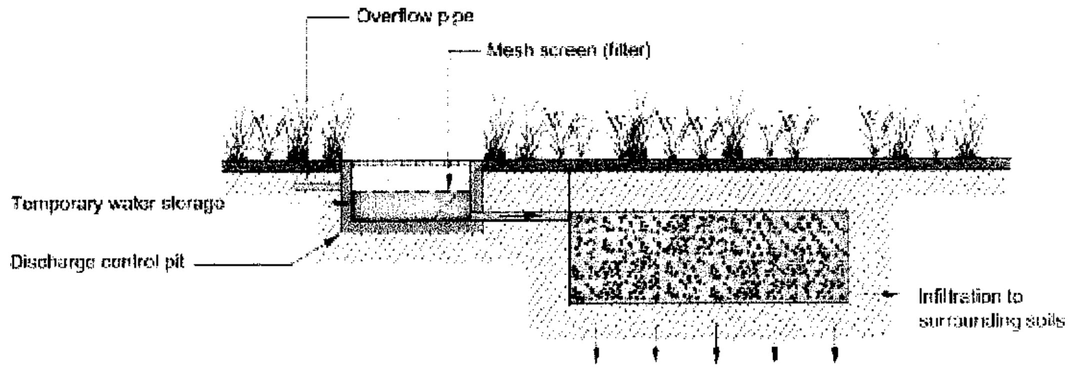

Figure 2.2: Operation of a gravel filled soakaway type infiltration system

Infiltration systems can be designed to achieve a range of objectives including:

- Minimising the volume of stormwater runoff from a development
- Preserving predevelopment hydrology
- Capturing and infiltrating flows up to a particular design flow
- Enhancing groundwater recharge or preserving predevelopment groundwater recharge.

The design objective will vary from one location to another and will depend on site characteristics, development form and the requirements of the receiving ecosystems. It is essential that these objectives are established as part of the conceptual design process and approved by the local authority prior to commencing the engineering design.

CHAPTER 3
METHODOLOGY/PROJECT WORK

3.1 Biochemical Oxygen Demand (BOD)

3.1.1 Apparatus

- BOD bottle, volume = 300ml
- Measuring cylinder
- Pipette
- DO probe equipped with a stirring mechanism

3.1.2 Procedure

1. Distilled water was prepared and aerated for 24 hours before it was used for BOD test.
2. 10 ml of samples were prepared and poured into the BOD bottles.
3. Then, the BOD bottle was topped up with distilled water that has been aerated for 24 hours until it reaches the neck of the BOD bottle.
4. Blank samples were also prepared by pouring only aerated distilled water in the BOD bottle.
5. After all the samples have been prepared, the initial dissolved oxygen, DO for each sample was measured using the DO probe that was equipped with a stirring mechanism.
6. The BOD bottles were then placed in the refrigerator at 20°C temperature and left for five days.
7. After five days of incubation, the final DO is measured by using the DO probe.
8. The BOD was calculated using the formula below:

BOD = (Initial DO – Final DO)/ (volume of sample/300)

3.2 Chemical Oxygen Demand (COD)

3.2.1 Apparatus

- Refluxing unit comprising the following:
  - Erlenmeyer flask – 250 ml capacity with standard joints
  - Condenser – Double jacketed with standard joints
  - Hot plate
- Oven – Set at 150°C
- Dispensers – to deliver accurate volume of chemicals
- Potassium dichromate solution, $K_2Cr_2O_7$

3.2.2 Procedure

1. 2 ml of water samples were measured and poured into a test tube containing potassium dichromate.
2. The test tube is then shaken properly. Heat was produced, indicating an exothermic process.
3. All the test tubes together with a blank as an indicator were then put into the rotator and left for 2 hours.
4. Three readings are taken and the average of those readings is calculated.

3.3 Total Suspended Solids (TSS)

3.3.1 Apparatus

- 47 mm filter paper
- Filter holder
- Filtering flask
- Watch glass
- Drying oven
- Measurement cylinder (1000 ml)

3.3.2 Procedure

1. A filter paper and wacth glass is weight using an analytical balance.
2. A 47 mm filter disc is placed in the filter holder with the wrinkled surface upward.
3. 100 ml sample is filtered followed with 10 ml washing of deionised water.
4. The vacuum is slowly released from the filtering system and the filter disc is gently removed from the holder. The filter disc is placed in watch glass.
5. The watch glass and filter is placed in a drying oven at 103°C for 1 hour.
6. The watch glass and filter is removed from the oven and carefully placed in desiccators. It is allowed to cool to room temperature.
7. The disc is carefully removed from the desiccator and weight using an analytical balance.

3.4 Ovitrap

3.4.1 Materials and Equipment

- 500ml mineral water bottle
- Spray paint (black)
- Scissor
- Hand saw
- ½ inch frame wood

3.4.2 Procedure

1. Cut the ½ inch frame wood about 12cm in length using a hand saw.
2. Cut the 500 ml mineral water bottle into two pieces using a scissor.
3. Place the bottles on a paper and paint it with a black spray paint.
4. Let the bottles dry in room temperature for 1 day.
5. After the bottles have dried, the top part of the bottle is placed reversely on top of the bottom part as shown in figure 3.1 below.

The bottle's mouth is fitted into the bottom part of the bottle that has been cut into two pieces.

Figure 3.1: Ovitrap

6. Fill in the bottle with tap water about half of its volume.
7. Put the frame wood that was cut accordingly into the bottle.
8. Place the ovitrap at the desired places and left it for 1 week.

9. After 1 week, collect the ovitraps and observe whether there is black spot on the wooden stisk which represent the mosquito egg.
10. Calculate the ovitrap index using the formula below.

$$\textbf{Ovitrap Index (OI)} = \frac{\textbf{No. of ovitrap containing larvae}}{\textbf{Total No. of ovitrap}} \times 100\%$$

CHAPTER 4
RESULTS AND DISCUSSION

For this project, about seven samples have been taken from sump with water stagnation problems in the drainage system at Taman Megah Tiga in Sitiawan and Taman Mas in Kampung Koh. The water samples were tests for pH, turbidity, BOD, COD and total suspended solids (TSS). The targeted number of samples for testing is 30 samples but only seven samples were taken and tested. All samples are taken from Taman Megah Tiga except for sample number 3 and 7 which are taken from UTP and Taman Mas respectively. The methodology and results for each tests stated above are described in detail below.

4.1 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand, BOD is an indirect indicator of the amount of the organic matter present in the water sample. In other words, BOD is the amount of oxygen used by bacteria to degrade the organic matter that present in the water. When bacteria are placed in contact with the organic matter, the bacteria will consume it as a food source. The organic matter will eventually be oxidized to stable end products such as carbon dioxide and water. From the result shown below, as a comparison between sample 1, 2 and 3, it can be seen that sample 3 has the lowest BOD. It is expected since the sample is taken at the sump in UTP near pocket C where the water is clear as compared to the other 2 samples. High BOD level indicates that the DO will decrease which may affect aquatic life in the water that help to prevent aedes mosquito from laying eggs. Sample 4 to 7 have a low BOD which is suitable for fish to live that help to control mosquito. In fact, there are fishes found at the location where sample 7 was taken. It is a good indication for further research on how to design a drainage system that is able to maintain the aquatic life that helps to control mosquito. BOD value is supposed to be lower than COD value. However, from the result, the BOD value is higher than COD value. This is mainly cause by the time constraint. The water samples for BOD cannot be kept for more than 24 hours and must be preserved in the incubator. However, since the distance between Manjung and UTP is quite far, the BOD test cannot be done on the same day and the samples have to be preserved in the incubator. The test was done on the following day. Therefore, the value of BOD was affected and that cause error in the results.

4.1.1 Results

BOD = (Initial DO – Final DO)/ (volume of sample/300)

Volume of sample = 10ml

Volume of BOD bottle = 300ml

Table 4.1: BOD value for sample 1 to sample 3

Sample	Before		After		DO depletion	BOD
	Temp.(°C)	DO	Temp.(°C)	DO		
Blank	21.02	8.77	20.88	7.7	1.07	1.07
1	23.38	8.42	22	6.6	1.82	54.6
2	23.02	8.14	22	7.19	0.95	28.5
3*	22.93	8.24	22.3	7.67	0.57	17.1

Note: *Sample taken at UTP for comparison

Volume of sample = 250ml

Table 4.2: BOD value for sample 4 to sample 7

Sample	Before		After		DO depletion	BOD
	Temp.(°C)	DO	Temp.(°C)	DO		
Blank	21.12	8.60	21	7.56	1.04	1.04
4	22.87	2.65	21.05	0.24	2.41	2.892
5	23.1	2.33	21.7	0.23	2.1	2.52
6	22.95	5.85	20.89	0.23	5.62	6.744
7*	22.7	6.06	20.9	0.25	5.81	6.972

Note: * Sample from Taman Mas

4.2 Chemical Oxygen Demand (COD)

Chemical oxygen demand, COD is widely used to characterize the organic strength of wastewater and pollution of natural waters. It is the amount of oxygen that is required to oxidize an organic compound to carbon dioxide, CO_2 and water under the influence of a strong oxidant, in this case $K_2Cr_2O_7$ in an acid environment. COD test is preferred as compared to BOD test as it requires a shorter time which is approximately three hours. Table below shows the result of COD tests. COD results are supposed to be higher than BOD results since it measures the biodegradable and non biodegradable organic matter while BOD measures only the biodegradable organic matter. But from the results, it is not align with the theory. This is cause mainly by error. Major sources of error are malfunction of the equipment for COD reading, the DO reading for BOD is taken when the DO probe is not stable and wrong volume of sample used in BOD test. The errors that are identified will be solved and the results will be improved in the next experiment.

4.2.1 Results

Table 4.3 COD value for water samples

Sample	COD reading (mg/L)
Blank	0
1	9
2	9
3	65
4	11
5	138
6	21
7	30

4.3 Total Suspended Solids (TSS)

Total suspended solids composed of floating matter, matter in suspension, colloidal matter and matter in solution. Total solids of water are defined as all the matter that remains as residue upon evaporation at 103°C to 105°C. Matter that has a significant vapor pressure at this temperature is lost during evaporation and is not defined as a solid. Total solids or residue upon evaporation can be classified as either suspended solids or filterable solids by passing a known volume of liquid through a filter. The filter is commonly chosen so that the minimum diameter of the suspended solids is about 1 micron. The suspended solids fraction includes the settleable solids that will settle to the bottom of a cone shaped container (Imhoff cone) in a 60 minutes period. The typical values of TSS of untreated domestic wastewater as shown in table below.

Table 4.4 Classification for TSS

	CONCENTRATION	(mg/L)	
	High	Medium	Low
Solids, total	1200	720	350
Suspended, total	350	220	100
Fixed	75	55	20
Volatile	275	165	80

As compared to the table above, it can be concluded that the TSS value of the samples are low. The highest value is from sample 7 which is 0.525 mg/L which is expected since there are some plants that has been degraded in the water sample. The TSS for some of the samples is high because the samples were taken at sump. The water from kitchen for a row of house flows into the sump. A lot of suspended solids can be seen in the water samples especially kitchen waste such as rice, chillies, and etc. All these suspended solids make the weight of filter paper high after drying which results in high concentration of suspended solids.

4.3.1 Results

The TSS is calculated using the formula below:

$$TSS = \frac{\text{(Weight of pan + filter paper after drying)} - \text{(Weight of pan + filter paper before drying)}}{\text{Sample Size (L)}}$$

Table 4.5: Results for Total Suspended Solids (TSS)

Sample	Sample Size (ml)	Weight of pan + filter paper before drying (mg)	Weight of pan + filter paper after drying (mg)	Total suspended solids (mg/L)	Average Total suspended solids (mg/L)
		1.2986	1.3002	0.016	
1	100	1.3066	1.3520	0.454	0.280
		1.2979	1.3348	0.369	
		1.2978	1.3072	0.094	
2	100	1.3228	1.3696	0.468	0.401
		1.2826	1.3466	0.640	
		1.3104	1.3206	0.102	
3	100	1.3264	1.3463	0.199	0.320
		1.2104	1.2764	0.660	
		1.3201	1.3413	0.212	
4	100	1.2927	1.3171	0.244	0.196
		1.3235	1.3366	0.131	
		1.3006	1.3297	0.291	
5	100	1.3600	1.3795	0.195	0.282
		1.3035	1.3394	0.359	
		1.3626	1.3987	0.361	
6	100	1.3524	1.3772	0.248	0.296
		1.3329	1.3608	0.279	

		1.3200	1.3402	0.202	
7	100	1.3131	1.4078	0.947	0.525
		1.3012	1.3437	0.425	

4.4 Turbidity and pH

4.4.1 Results

Table 4.6: Results for turbidity and pH

Sample	Turbidity, NTU	pH	Temperature (°C)
1	24.6	7.310	28.3
2	32.3	7.412	28.1
3	1.40	8.621	29.8
4	23.4	7.362	21.5
5	74.1	6.496	21.3
6	11.5	6.725	21.0
7	38.5	7.636	21.5

The pH for all the samples are ranging from 6.4 to 8.7 which is consider as neutral because it is near to 7 except for sample 3 which is a little bit higher. It is quite neutral since the water sample is taken from housing area with no toxic waste flowing into the drain if compared to samples taken from industrial area where toxic waste is discharge into the drain. The pH value can be lower (acid) although it has been treated before it is discharged into the drain. From the result above, the possibility of using guppy or Gambusia fish for larvae control can be considered since the fish can survive at a pH ranging from 6.5 to 9.9 (JR Lardeux, 1992, p.5).

4.5 Ovitrap

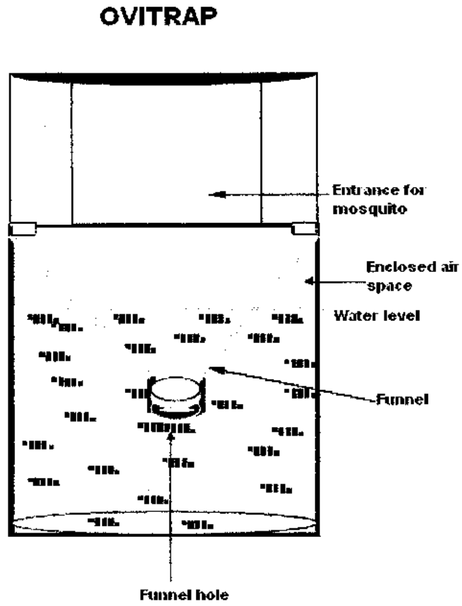

Figure 4.1: Ovitrap

Figure 4.1 above shows the standard ovitrap that is used by Jabatan Kesihatan to determine the ovitrap index. However, when the standard ovitrap is not available, Jabatan Kesihatan also use a self made trap made of mineral water bottle. A wooden stick is placed in the ovitrap to provide place for the mosquito to breed. The water in the ovitrap will wet the wooden stick by capillary pressure. The wooden stick can be replaced with anything that has a rough surface such as tissue paper. For this project, mineral water bottles are used to make the ovitrap. The bottle was cut into two sections. Then, it was sprayed with black paint to create a dark environment for a female mosquito to breed since female mosquito likes dark places. The ovitrap is shown in the figure 4.2 below:

Figure 4.2: The figure shows a photo of an ovitrap made of mineral water bottle and sprayed with black paint.

Fifeteen (15) ovitraps have been placed in Universiti Teknologi Petronas (UTP) around village 4 residential college and another 15 along the main road from the mosque to village 4. Generally, in the residential college, the ovitraps are place at every corner of the block at the drainage sump and at the entrance near the flower pots. Along the main road, the ovitrap research is more focus towards engineering structures such as sump, sluice valve chamber and water hydrant. For water sluice valve chamber, the ovitrap is placed at the corner of the structure as shown in figure 4.3 below:

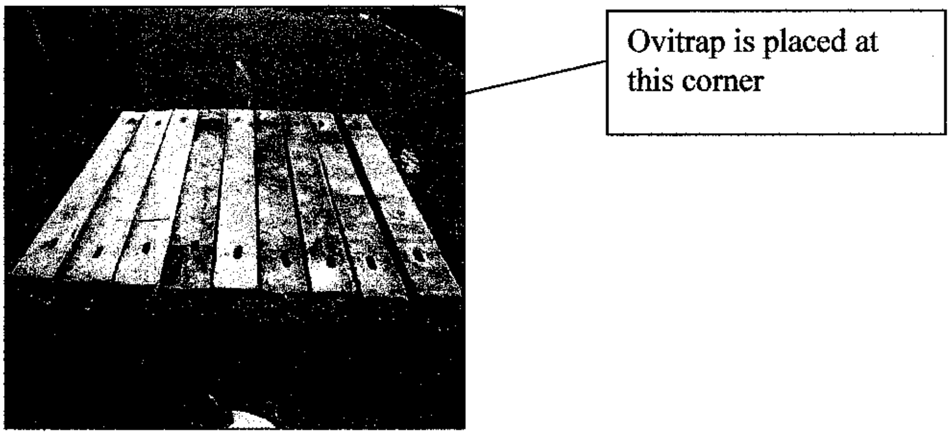

Figure 4.3: A photo of the location where the ovitrap was placed for sluice valve chamber.

For sump, the ovitrap is tied to the grating of the sump as shown in figure 4.4 below:

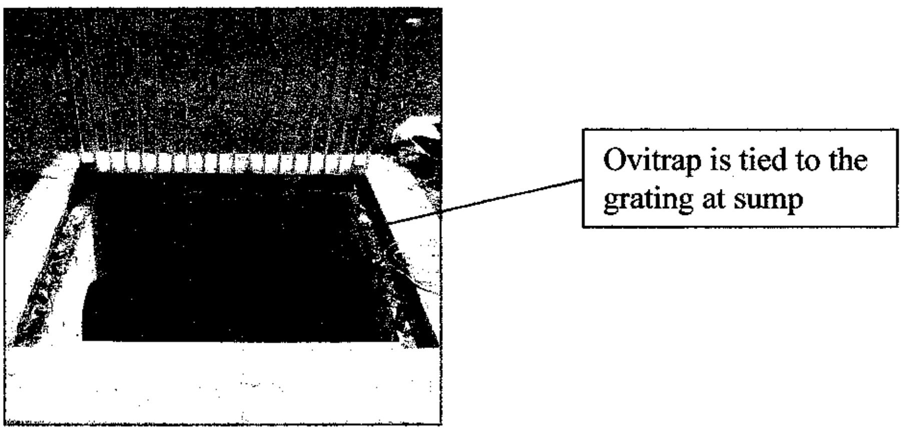

Figure 4.4: A photo showing the location where the ovitrap was placed for sump

Out of 15 ovitraps placed around village 4 residential college, 7 of it contain mosquito larvae. The larvae can be identified by the black spots on the wooden stick. Five out of another 15 ovitraps placed along the main road contain mosquito larvae. Therefore, a total of 12 ovitraps contain mosquito larvae from 30 ovitraps that have been done. The ovitrap index for UTP is calculated using the formula below:

$$\textbf{Ovitrap Index (OI)} = \frac{\textbf{No. of ovitrap containing larvae}}{\textbf{Total No. of ovitrap}} \times 100\%$$

Therefore:

$$\textbf{OI for UTP} = \frac{12}{30} \times 100\% = 40\%$$

From research that has been done by Institute of Medical Research (IMR), if the ovitrap index (OI) = 10% or above, the study area is exposed to risk of dengue outbreak and the necessary action should be taken. That's why there has been fogging activity been going on in UTP lately since there is dengue case here in UTP.

In this study, precautions have to be considered to obtain an accurate data. In this study, there were some problems encountered whereby result cannot be obtained from some of the ovitraps since some of it was lost and some was damaged due to heavy rain. Therefore, the ovitraps should be placed at shaded area out of the visibility of people where there is possibility that the person will throw away the ovitrap.

4.6 Assessment of Engineering Structures in UTP

After doing field work assessment of drainage system in Manjung, specifically Taman Mas and Taman Megah Tiga, the fieldwork continues with the assessment of engineering structures such as drainage sump or sand trap, water distribution valve box and fire hydrant sluice valve box in Universiti Teknologi Petronas (UTP). A total of 40 structures have been assessed which consists of 25 drainage sump and 15 sluice valve chamber. These structures have been known to hold water especially sluice valve chamber. From the assessment that have been done, sluice valve chamber can retain a large amount of water up to 3 meters depending on the depth of the structure.

4.6.1 Results

The assessment of the engineering structures is done by measuring the depth of water retained in each structure. Table 4.7 below shows the result of water depth for drainage sump.

Table 4.7: Size of structures and depth of water retained in drainage sump

Sump	Size		Water depth (cm)	Surface area (m^2)
	Length, L (cm)	Width, W (cm)		
1	112	88	9	0.99
2	88	88	7	0.77
3	80	88	4	0.70
4	127	115	26	1.46
5	124	110	20	1.36
6	109	112	7	1.22
7	132	168	6	2.22
8	123	122	3	1.50
9	240	213	14	5.11
10	125	118	15	1.48
11	75	68	4	0.51
12	220	205	25	4.51
13	145	130	9	1.89
14	125	122	2	1.53
15	148	135	10	2.00
16	105	90	4	0.95
17	78	60	5	0.47
18	250	238	18	5.95
19	135	133	12	1.80
20	142	137	3	1.95
21	85	83	4	0.71
22	188	175	27	3.29
23	200	190	22	3.80
24	88	88	10	0.77
25	85	85	7	0.72

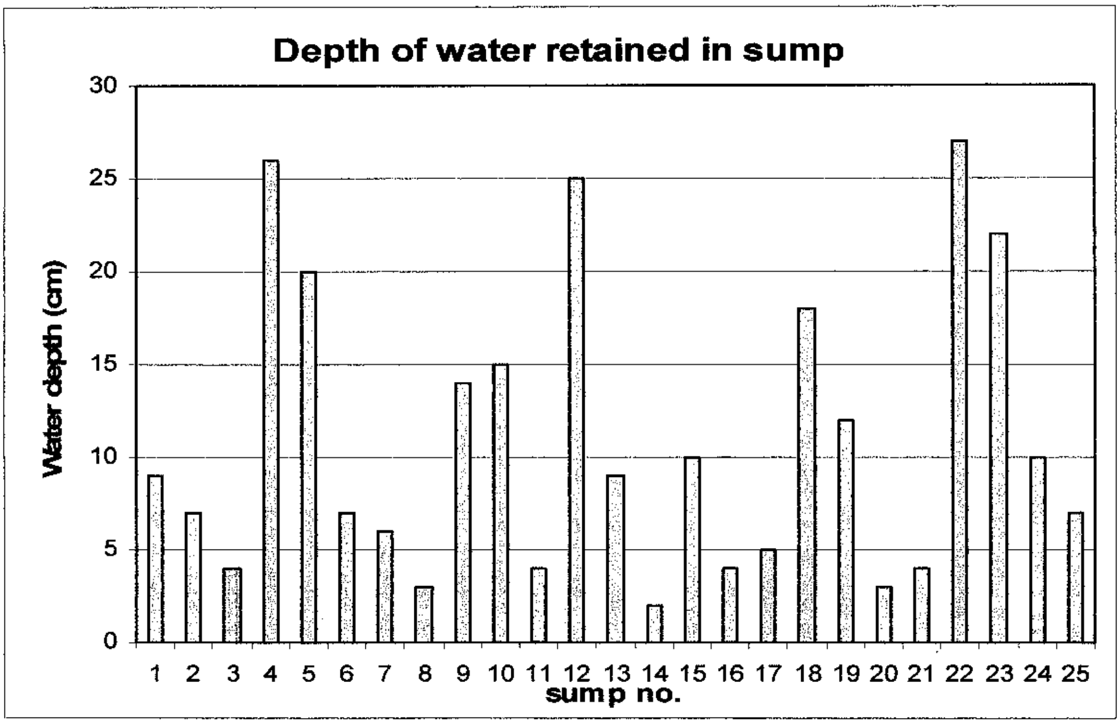

Figure 4.5: Bar chart showing depth of water retained in drainage sump

From figure 4.5 above, it can be seen that a drainage sump can retain water up to depth of 27cm which provide ample spaces for the mosquito to breed as it can breed in water depth as low as 1mm, provided that the sump is located at ideal place such as under a tree or shaded area. The water surface area also plays a major role in the quantity of mosquito. Aedes mosquito laid their eggs on the water surface. Therefore, the larger the structure, more spaces are provided for mosquito to lay eggs and increase the quantity of mosquito larvae. Figure 4.6 below shows bar chart representing the water retained in drainage sump in term of surface area of the structure. As for sluice valve chamber, the results are shown in table 4.8 below.

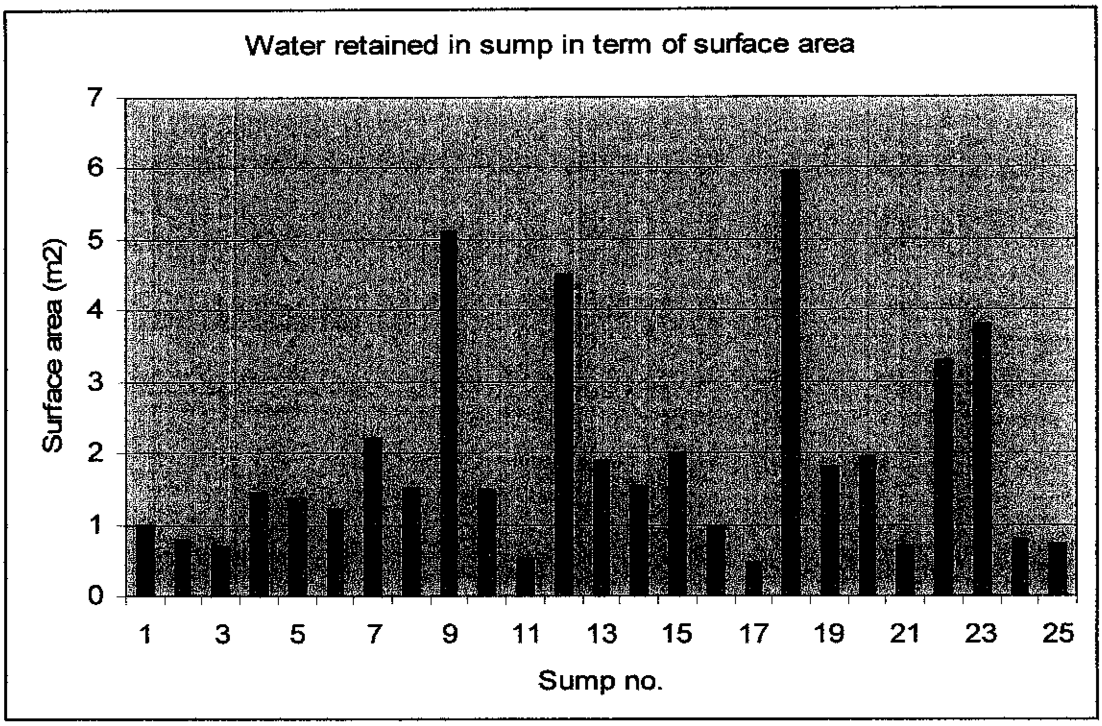

Figure 4.6: Bar chart representing the water retained in drainage sump in term of surface area of the structure

Table 4.8: Size of structure and depth of water retained in sluice valve chamber

Sluice box	Size		Water depth (cm)	Depth (cm)	Surface area (m2)
	Length, L (cm)	Width, W (cm)			
1	273	203	90	280	5.54
2	184	195	31	205	3.59
3	260	223	45	290	5.80
4	300	307	100	250	9.21
5	155	162	55	190	2.51
6	280	255	280	300	7.14
7	130	135	27	235	1.76
8	160	178	50	220	2.85
9	255	225	125	180	5.74
10	290	290	53	285	8.41
11	185	182	72	220	3.37
12	198	198	78	238	3.92
13	220	235	80	200	5.17
14	250	270	92	230	6.75
15	286	270	130	210	7.72

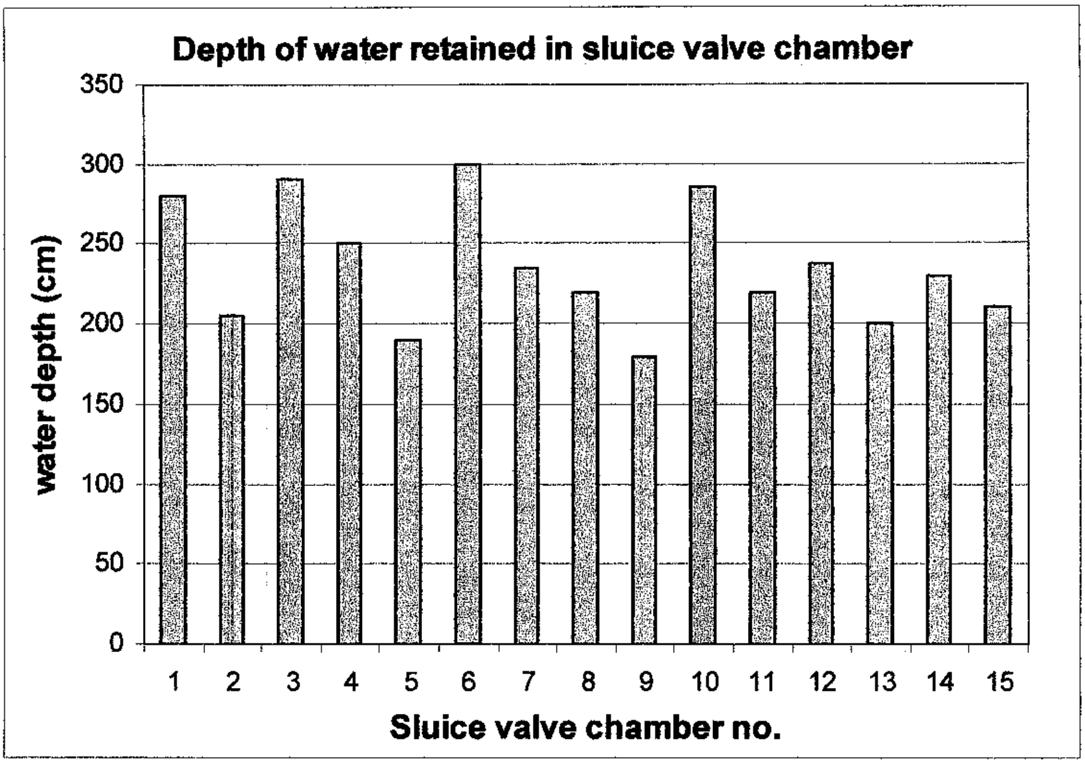

Figure 4.7: Bar chart showing depth of water retained in sluice valve chamber

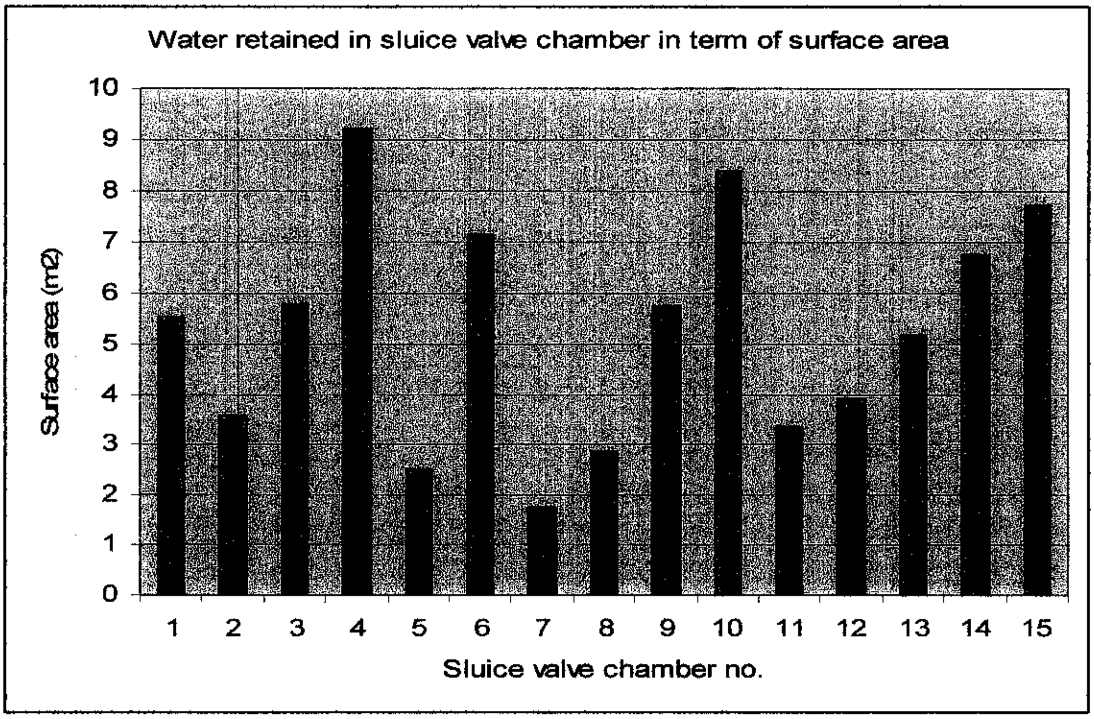

Figure 4.8: Bar chart representing water retained in sluice valve chamber in term of surface area.

As can be seen from figure 4.7 above, depth of water retained in sluice valve chamber is in range of 27 cm to 280 cm. Figure 4.8 shows the same data plotted in term of the surface area of the structure. Larger surface area provides more space for mosquito to lay their eggs which is the same with drainage sump. The water can become a breeding ground for Aedes mosquito as it is clean and clear water from rain as can be seen in figure 4.9 below. Moreover, the condition in the valve chamber is very dark. Therefore, it is an ideal place for mosquito to breed since female mosquito love to breed in dark places.

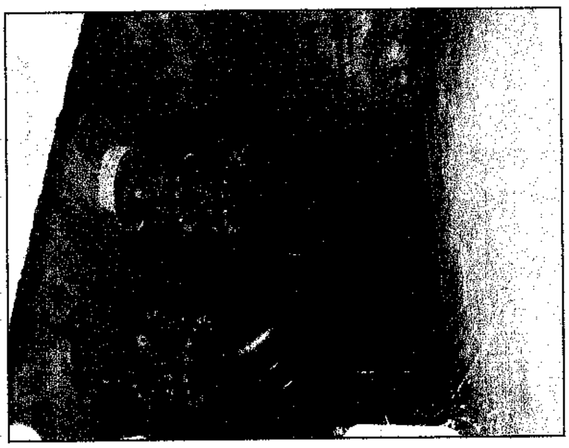

Figure 4.9: Water retained in a sluice valve chamber

4.7 Method of Mosquito Control

4.7.1 Structural Modification on the Existing Design (Soakaway Pit)

As shown by the result, a modification on the existing design of these structures especially for sluice valve chamber needs to be done. From the survey and observation that has been done on sluice valve chamber in UTP, it is clear that the concrete at the base of the chamber prevent water from seeping to the ground. It is not a big concern for drainage sump since this structure is normally located at open space which is subjected to open sun light and it is not covered. Therefore, the likelihood of mosquito breeding in sump is much lower than in sluice valve chamber as it is covered with concrete bars which prevent sun light from entering the structure and thus provides an ideal, dark place for mosquito to breed.

A soakaway pit can be introduced alongside sluice valve chamber to convey the accumulated water into the ground. The suitability of a site for soakaway pit must be determined before designing soakaway pit which is one type of infiltration structures including vegetated swale, infiltration trench, and etc. In determining the suitability of a given site for a soakaway pit, several factors must be considered including contributing drainage area, underlying soil type, depth to water table, bedrock or other impeding layer, proximity to building and etc. Soil investigation is done to determine the soil type. A soil can be considered for soakaway pit if the measured infiltration rate is at least 0.5 in/hr and less than 5 in/hr (Dr. Madison, 2004, p.11). The soakaway pit should be filled with gravel and lined at the side, top and bottom with an appropriate geotextile fabric.

There are two types of soakaway pit normally designed. The first one is shown in figure 4.10 below. In the figure below, perforated pipe is not use. The water is directly conveyed to the soakaway pit. The second design is shown in figure 4.11 below. In the figure, the water is conveyed to the pit and will seep into the ground through the perforated pipe.

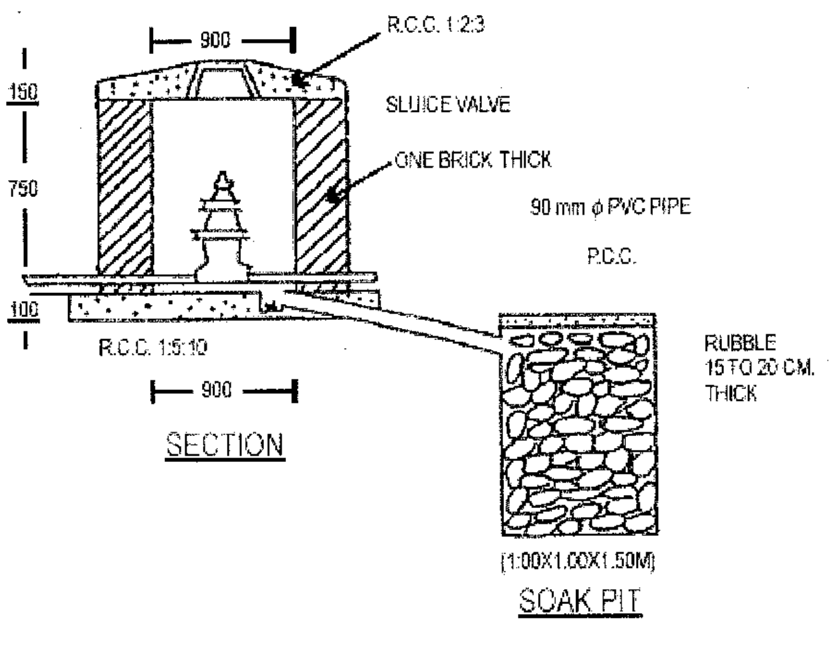

Figure 4.10: Design of soakaway pit for sluice valve chamber

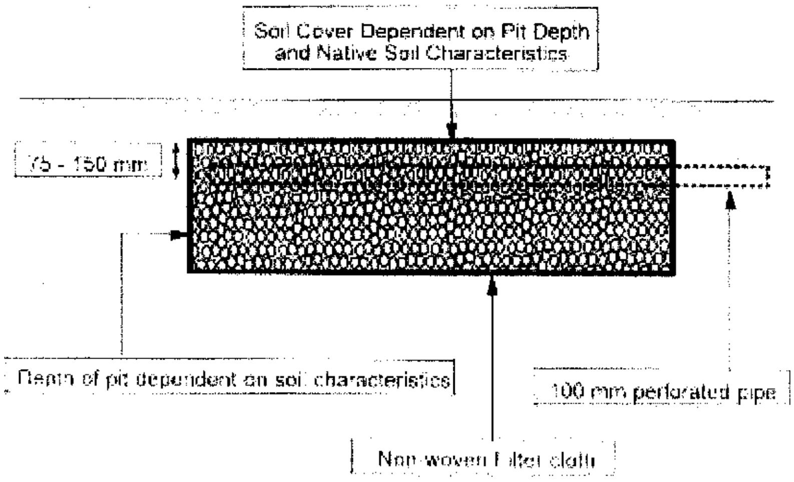

Figure 4.11: Soakaway pit using perforated pipe

Source: Ontario Ministry of Environment, 1999

4.7.2 Chemical Control Using Larvicides

Larvicides kill mosquito larvae. Larvicides include biological insecticides, such as the microbial larvicides *Bacillus sphaericus* and *Bacillus thuringiensis israelensis*. Larvicides include other pesticides, such as temephos, methoprene, oils, and monomolecular films. Larvicide treatment of breeding habitats helps reduce the adult mosquito population in an area. Larviciding involves applying pesticides to breeding habitats to kill mosquito larvae. Larviciding can reduce overall pesticide usage in a control program. Killing mosquito larvae before they emerge as adults can reduce or eliminate the need for ground or aerial application of pesticides to kill adult mosquitoes.

Microbial Larvicides

Microbial larvicides are bacteria that are registered as pesticides for control of mosquito larvae in outdoor areas such as irrigation ditches, flood water, standing ponds, woodland pools, pastures, tidal water, fresh or saltwater marshes, and storm water retention areas. Duration of effectiveness depends primarily on the mosquito species, the environmental conditions, the formulation of the product, and water quality. The microbial larvicides commonly used for mosquito control are Bacillus thuringiensis israelensis (Bti) and Bacillus sphaericus (B. sphaericus).

Bacillus thuringiensis israelensis is a naturally occurring soil bacterium registered for control of mosquito larvae. Bti was first registered by Environmental Protection Agency (EPA) as an insecticide in 1983. Mosquito larvae eat the Bti product that is made up of the inactive spore form of the bacterium and an associated pure toxin. The toxin disrupts the gut in the mosquito by binding to receptor cells present in insects, but not in mammals. There are a lot of Bti products such as Aquabac, Teknar, Vectobac and LarvX.

Bacillus sphaericus is a naturally occurring bacterium that is found throughout the world. *B. sphaericus* was initially registered by EPA in 1991 for use against various kinds of mosquito larvae. Mosquito larvae ingest the bacteria, and as with *Bti*, the toxin disrupts the gut in the mosquito by binding to receptor cells present in insects but not in mammals. VectoLex CG and WDG are registered *B. sphaericus* products and are effective for approximately one to four weeks after application.

Abate (Temephos)

Abate is an organophosphate material delivered as a plaster pellet, liquid, or sand granule with a relatively low toxicity. The larvicide is effective against the floodwater mosquitoes, but is often used as a larvicide in polluted larval habitats. This insecticide has been used by the World Health Organization to treat stored drinking water. However, careless handling or ingestion of any organophosphate increases health risks. At high dosage, Temephos can over stimulate the nervous system causing nausea, dizziness and confusion. As with any insecticide special attention to the label is necessary relative to site use, mixing, and application of material.

Monomolecular Films

Monomolecular films like Agnique and Arosurf spread across the water to decrease its surface tension making it difficult for larvae, pupae, and emerging adults to attach to the water surface, causing them to drown. These films are effective in treating mosquito habitat without significant surface vegetation.

Petroleum Hydrocarbons

Petroleum Hydrocarbons, with trade names Golden Bear and Bonide, are highly refined mineral oils used in larviciding/pupaciding practices. The mineral oil covers the surface of the water and then enters the breathing tubes of the larvae/pupae as they surface, making it impossible for them to breath. This larvicide offers effective larval control in all larval habitats. In Taman Megah Tiga in Manjung, a thin layer of oil has been observed at section of the drain behind a row of shop houses as shown in figure 4.12 below. The people living in the area have been given education on how to reduce mosquito breeding from frequent visit by the health department of Manjung district since there have been many cases of dengue in the area.

Figure 4.12: Oil is used to control mosquito breeding in Taman Megah Tiga, Manjung, Perak.

4.7.3 Biological Control

Fish have been widely used in public health, since as early as 1903. One of the most successful and widely used biological control agents against mosquito larvae is mosquito fish *Gambusia affinis*. Fish other than *Gambusia* which has received the most attention as a mosquito control agent is *Poecilia reticulata*, the common guppy.

Fish have been extensively used for mosquito control in the urban malaria scheme under the National Anti Malaria Programme in India and several other countries. Fish is used because of its advantages that are listed below:

- These fishes are self-perpetuating after its establishment and continue to reduce mosquito's larvae for long time.
- The cost of introducing larvivorous fish is relatively lower than that of chemical control.
- Use of fish is an environment friendly method of control.
- Larvivorous fish such as *Gambusia* and *Poecilia* prefer shallow water where mosquito larvae also breed.

Gambusia affinis

Gambusia affinis has been in use in India since 1928. It is an exotic species and has been distributed throughout the warmer and some temperate parts of the world. It is a very hardy fish and can adapt to wide variations in temperature as well as to chemical and organic content of the water but does not tolerate very high organic pollution. The optimum temperature for reproduction ranges from 24°C to 34°C but the fish can survive at freezing temperatures. The most suitable pH of water is between 6.5 and 9.9 (JR Lardeux, 1992, p.5).

Gambusia is really suitable for the mosquito larvae since it is effective in eating the larvae. A single full grown fish eats about 100 to 300 mossquito larvae per day (JR Lardeux, 1992, p.8). It lives and multiplies in ponds stocked with larger fish provided pond is shallow and has protective vegetation for refuge. The maximum size attained by a male is 4.5 cm. and by a female 5.2 cm to 6.8 cm. Its life span is approximately 4 ± 1 years.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

This project focuses on assessment of the existing drainage system at the study area to examine the design consideration that lead to water stagnation. The next step is to further improve the design by proposing new structure either to prevent stagnation that becomes breeding ground for aedes mosquitoes or to provide the management control. For this project, water samples were collected and tested for the quality. Seven samples were collected from sump and tested

Major problem in this project is in collecting water sample and to meet the required detention time for doing the tests on water sample. Water samples need to be collected in Manjung which is quite far from UTP. The water samples can be preserved in incubator for a maximum of three days. If it is kept for longer time, the result for BOD and COD will be affected significantly. Furthermore, there are four tests that need to be done for each sample which require a lot of time. Therefore, not much samples can be collected at one time because test especially on BOD and COD must be done as soon as possible so that it will not exceed three days. Another problem is the accuracy of result that is obtained from the experiment. There are errors occur during experiment such as equipment malfunction, human error and wrong technique of doing experiment which affect the results obtained.

In the assessment of engineering structures in UTP, major problem occur is the accessibility of the structure especially for sluice valve chamber. Since the sluice valve chamber is covered with concrete blocks which are heavy, it is difficult to observe and measure the water depth retained in the structure. As a conclusion, since the structures are proven to retain water, a quick action has to be made to eliminate mosquito larvae as discussed in the discussion part whether to use chemical, biological or structural method in order to control mosquito breeding.

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