A STUDY OF STORMWATER RUNOFF QUANTITY AND QUALITY MONITORING IN UMP GAMBANG

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Thank you.

ABSTRAK

Air larian permukaan merupakan penyumbang utama pencemaran di sungai, dan tasik di seluruh negara. Air larian permukaan mengandungi bahan tercemar dari banyak sumber yang berbeza, oleh itu pengurangan kadar pencemaran dari air larian permukaan merupakan tugas yang sangat mencabar. Ia memerlukan kerjasama daripada penduduk, peniaga, dan majlis perbandaran. Langkah penting dalam melindungi sungai dari pencemaran air adalah pemahaman proses aliran kawasan tadahan, ciri-ciri air larian permukaan dan kesan gabungan pada aliran air dan kualiti air. Objektif kajian ini adalah analisis hubungan antara sifat hujan dan kriteria hujan dan Jumlah Pepejal Terampai di UMP Gambang. Data ini dikumpulkan pada bulan Disember 2017 sehingga Mac 2018. Alat Pengsampelan Air Mudahalih digunakan untuk mengumpul sampel Jumlah Pepejal Terampai, manakala peralatan tolok hujan digunakan untuk mengkumpulkan kedalaman hujan. Sampel dibawa ke makmal alam sekitar untuk eksperimen Jumlah Pepejal Terampai. Hasilnya pada Disember mempunyai satu kejadian hujan, Januari mempunyai lima kejadian hujan dan Februari mempunyai dua kejadian hujan. Hubungan air larian permukaan di antara kedalaman hujan dan Jumlah Pepejal Terampai boleh dikaitkan dengan keadaan semakin lama tempoh hari tidak mempunyai hujan sebelum hujan turun , semakin tinggi nilai Jumlah Pepejal Terampai semasa hujan turun.

ABSTRACT

Stormwater runoff is a leading contributor to pollution in streams, rivers, and lakes in nationwide. Thus stormwater runoff contains pollutants from many different sources, therefore decreasing pollution from stormwater runoff is a challenging task. It requires cooperation from residents, businesses, and municipalities. An important step in protecting streams from stormwater pollution is understanding watershed processes, stormwater characteristics, and their combined effects on streams and water quality. The objective of the study was analysis relationship between rainfall characteristic and Total Suspended Solid (TSS) at UMP Gambang. The data was collected in December 2017 until March 2018.The Portable Water Sample used to collect sample of Total Suspended Solid (TSS), meanwhile equipment Rain Gauge was collected rainfall depth. The sample are taken to environmental laboratory for Total Suspended Solid experiment. The result in December has an event, January has five events and in February has two events. The stormwater runoff relationship between rainfall depth and TSS can be taken as the longer period of rainless before rain, the higher value of Total Suspended Solid (TSS) during rain.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

TSS	Total Suspended Solid
USEPA	United States Environmental Protection Agency's
US	United States

LIST OF ABBREVIATIONS

TSS	Total Suspended Solid
INWQS	Interim National Water Quality Standard

CHAPTER 1

INTRODUCTION

1.1 Background Study

Stormwater runoff is the nation's number one source of water pollution. Stormwater runoff is water from rain or melting snow that “runs off” across the land instead of seeping into the ground. Stormwater is rain (also melting snow and ice) that washes off driveways, parking lots, roads, yards, rooftops, and other hard surfaces. Stormwater picks up pollution, such as chemicals, bacteria, sediment, and trash, and washes these things into ditches and storm drains, and then into creeks, rivers, ponds, and lakes. This is referred to as stormwater runoff.

Polluted runoff generally happens anywhere people use or alter the land. For example, in developed areas, none of the water that falls on hard surfaces like roofs, driveways, parking lots or roads can seep into the ground. These impervious surfaces create large amounts of runoff that picks up pollutants. The runoff flows from gutters and storm drains to streams. Runoff not only pollutes but erodes stream banks. The mix of pollution and eroded dirt muddies the water and causes problems downstream.

Combined sewer overflows and separated sewer overflows (CSOs, SSOs) are well known for their overflows of untreated wastewater during storm events. CSOs and SSOs are typically composed of wastewater and surface runoff from urbanized areas (Lee, 1996). Nonpoint pollution resulting from stormwater runoff has been identified as one of the major causes of the deterioration of the quality of receiving waters. The street solids and sewer-deposited material are major pollutants in urban runoff (Field et al., 1982; Novotny and Olm, 1994; Bang et al., 1997). And characteristics of urban runoff are more difficult to qualify than are those of wastewater. CSOs and SSOs from a large storm event may shock the receiving water body many times greater than an ordinary effluent load (Loehr, 1974; Bedient et al., 1978; Field et al., 1994). Therefore, the characterization of stormwater runoff pollutant is necessary for a water quality management plan to urban stream.

Stormwater runoff and quality parameters such as biochemical oxygen demand (BOD5), chemical oxygen demand (COD), suspended solids (SS), total Kjeldahl nitrogen (TKN), nitrate–nitrogen (NO3–N), orthophosphorus (PO4–P), total phosphorus (TP), n-Hexane extracts, lead (Pb) and iron (Fe) were analyzed for the development of relationships between runoff and water quality.

Figure 1.1 Polluted Water

Source: EPA United States Environmental Protection Agency

Figure 1.2 Stormwater Pollution

Source: EPA United States Environmental Protection Agency

1.2 Problem Statement

Sediment is the number one water quality pollutant originating from water runoff in urban area. Area which is impervious usually experienced sediments greater than those under natural land cover conditioned do. This results in sediments being discharged and chokes into receiving waters during rainy days.

High levels of sedimentation in drain leads to physical disruption of the hydraulic characteristics of the channel. This can lead to increased flooding because of reductions in capacity of the drainage channel to efficiently route water through the drainage basin. When storm drains become clogged with trash and debris, it can result in street and neighborhood flooding during the rainy season. This water backup can lead to closed roads and increased traffic, and create an unhealthy environment of smelly and unsanitary conditions in communities, worsening local aesthetics and lowering property values.

Storm water pollution also poses public health threats in our neighbourhoods, trash and animal waste left on the ground carry harmful disease- spreading bacteria, putting children and their families at risk in their local communities. In addition, when not manage stormwater properly, for instance is flooding of transportation corridors and damage to properties.

1.3 Objective of Study

From the problem statement mentioned before, the study is conduct in order to achieve the following objective:

i. To determine the Total Suspended Solid (TSS) in stormwater runoff.

ii. To analyse the relationship between rainfall pattern and TSS.

1.4 Scope of Study

i. The area of study is in Universiti Malaysia Pahang, Gambang.

ii. Portable Water Sampler is used to collect the sample of sediment for laboratory testing.

iii. The experiment for Total Suspended Solid (TSS) is conducted in Environmental Laboratory UMP Gambang campus.

iv. The monitoring of rainfall and runoff are conducted from December 2017 until May 2018.

v. Rainfall data are collected from rain gauge.

1.5 Significant of Study

From this analysis, the estimation of sediments varies with rainfall can be determined. This study is crucial as its give important data to design sediment trap/filtering especially for the first flush. It is also important for the future to promote environmentally drainage design in urban area. Proper drainage can be design on development site to reduce sediments in urban area. Avoid excessive use of hard surfaces that create inappropriate water flows and prevent stormwater percolating into the ground. The resident can enhance the urban landscape for example, diversion channels and trenches that filter sediment can be used with rubble in the base to create a deep root planting opportunity to control the sediment.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Construction industry is one of the causes occurrence of environmental it is deposition, it can cause damage in river, lake, wetland, and ocean. When rainwater overflow a construction site, it detects pollutant like sediment, debris, and chemical substance. Preventing soil erosion and deposition is an important task in all construction site.

Construction areas have substantial exposed surfaces that erode in the right conditions (e.g. rain or strong winds). Runoff from these sites carries sediments into drainage networks and then to ecosystems downstream (rivers, lakes etc). These are many examples of poor sediment and erosion control practices leading to increased sedimentation, reduced clarity and algae blooms in downstream waters. There are many ways in which construction sites can be managed to reduce these impact.

In addition, water pollution (stormwater) probably include sediment (land eroded). Stormwater draining off an area from the rain dropping from roof to the ground. It is only referring to rain that collapsed over roof, which normally there is cleaner. When stormwater experienced pollution when alighting to the ground because is generated stormwater by rain run from roof, road, access road, lane and other surfaces that impervious or hard. During the storm drain have dirt like trash it is bacteria (for example, coliform E. coli and faeces from wastes pamper and sewage / septic systems), nutrient and toxic organic it is chemicals (like fertilizer, soap, pesticide, oil, grease, gas, and antifreeze), toxic inorganic chemistry (heavy metal like lead, zinc, copper and cadmium) and contaminants other (Robin G. Mclnnes et al, 2002)

2.2 Sedimentation

Nonpoint source pollutants come from a number of sources and are washed into our waterways by surface runoff. When land disturbing activities occur, soil particles are transported by surface water movement. Soil particles transported by water are often deposited in streams, lakes, and wetlands. This soil material is called sediment. Sediment is the loose sand, clay, silt and other soil particles that settle at the bottom of a body of water. Sediment can come from soil erosion or from the decomposition of plants and animals. Wind, water and ice help carry these particles to rivers, lakes and streams.

Sedimentation, or clarification, is the processes of letting suspended material settle by gravity. Suspended material may be particles, such as clay or silts, originally present in the source water. The deposition of sedimentation for soil particles that have been transported by water or wind. Sedimentation occurs when the water in which the soil particles are carried is sufficiently slowed for a long enough period of time to allow particles to settle out. The size and quantity of the material transported increase with the velocity of the runoff. The heavier or bigger particles like gravel and sand, settle out sooner than to do finer particle, such as clay. The length of time a particle stays in suspension increase as the particle size decrease (Bogen, 1992).

2.2.1 Sedimentation at Construction Site

Gullies are the major sediment source on exposed construction sites. Gullies increase in size more rapidly on filled materials than on cut slopes. Down cutting is the dominant gully enlargement process in cut material while sidewall retreat dominates on fill (DID, 2000).

2.2.2 Impact of Sedimentation

Sedimentation of surface waters can cause stream channels to become clogged with sediment. When stream channels become clogged, the result will be an increase in bank erosion, meandering, and flooding. Sediment also reduces the storage capacity of reservoirs, destroys wetland areas, and degrades the quality of water for municipal, industrial, and recreational uses.

The serious consequence of sedimentation is well known. Currently the efficiency of mitigation measure in reducing the impact of sedimentation on the environment and receiving water is little known. Onsite and off-site effects of soil, sediment transport, siltation and deposition (Institution of Engineering Singapore, 2004) are as follows:

a) On-site

i. Loss of topsoil and resulting cost to communities.
ii. Clogged drains and increased nuisance flooding.
iii. Sedimentation and bank damage on construction sites.
iv Sediment and mud on roads with associated traffic problems and road safety issues.
v Sedimentation and eccelarated loss of capacity in sediments basin.

b) Off-site

i. Increased pollution of rivers and streams.
ii. Instability of stream channels caused by increased runoff and sediment load channel change and bank erosion may effect adjacent building and other infrastructure.
iii. Sedimentation in reservoir and other storage structures, with resulting loss of water storage capacity.
iv Siltation and sedimentation of river will cause a reduction in channel capacity leading to greater frequency of floods.

2.2.3 Types of Sediment Transport

Sediment transport is a direct function of water movement. During transport in a water body, sediment particles become separated into three categories: suspended material which includes silt + clay + sand; the coarser, relatively inactive bed load and the saltation load (Jamie, B. and Richer, B. 1996).

Suspended load comprises sand + silt + clay-sized particles that are held in suspension because of the turbulence of the water. The suspended load is further divided into the wash load which is generally considered to be the silt + clay-sized material (< 62 μm in particle diameter) and is often referred to as ―fine-grained sediment. The wash load is mainly controlled by the supply of this material (usually by means of erosion) to the river. The amount of sand (>62 μm in particle size) in the suspended load is directly proportional to the turbulence and mainly originates from erosion of the bed and banks of the river. In many rivers, suspended sediment (i.e. the mineral fraction) forms most of the transported load (Jamie, B. and Richer, B. 1996).

Bed-load is tiny material, such as gravel and cobbles that moves by rolling along the bed of a river because it is too heavy to be lifted into suspension by the current of the river. Bed-load is especially important during periods of extremely high discharge and in landscapes of large topographical relief, where the river gradient is steep (such as in mountains). It is rarely important in low-lying areas. Measurement of bed-load is extremely difficult. Most bed-load movement occurs during periods of high discharge on steep gradients when the water level is high and the flow is extremely turbulent. Such conditions also cause problems when making field measurements (Ongley, E.D. 1992).

Despite many years of experimentation, sediment-monitoring agencies have so far been unable to devise a standard sampler that can be used without elaborate field calibration or that can be used under a wide range of bedload conditions. Even with calibration, the measurement error can be very large because of the inherent hydraulic characteristics of the samplers and the immense difficulty with representative sampling of the range of sizes of particles in transit as bed-load in many rivers. Unless bed-load is likely to be a major engineering concern (as in the filling of reservoirs), agencies should not attempt to measure it as part of a routine sediment-monitoring programme. Where engineering works demand knowledge of bedload, agencies must acquire the specialised expertise that is essential to develop realistic field programmes and to understand the errors associated with bedload measurement. Local universities or colleges may be able to assist in this regard (Yalin, M.S. 1977).

Saltation load is a term used by sedimentologists to describe material that is transitional between bed-load and suspended load. Saltation means ―bouncing‖ and refers to particles that are light enough to be picked off the river bed by turbulence but too heavy to remain in suspension and, therefore, sink back to the river bed. Saltation load is never measured in operational hydrology (Ongley, E.D. Yuzyk, T.R. and Krishnappan, B.G., 1990).

2.2.4 Sediment Measurement

While the underlying theory is well known, the measurement of sediment transport requires that many simplifying assumptions are made. This is largely because sediment transport is a dynamic phenomenon and measurement techniques cannot register the ever- changing conditions that exist in water bodies, particularly in river systems. Some of the sources of extreme variability in sediment transport are discussed in next sub-chapter.

2.2.5 Particle Size

Knowledge of the size gradient of particles that make up suspended load is a prerequisite for understanding the source, transportation and, in some cases, environmental impact of sediment. Although particles of sizes ranging from fine clay to cobbles and boulders may exist in a river, suspended load will rarely contain anything larger than coarse sand, and in many rivers 50-100 per cent of the suspended load will be composed only of silt + clay- sized particles (<62 μm). The size of particles is normally referred to as their diameter although, since few particles are spherical, the term is not strictly correct. Particle size is determined by passing a sample of sediment through a series of sieves, each successive sieve being finer than the preceding one. The fraction remaining on each sieve is weighed and its weight expressed as a percentage of the weight of the original sample. The cumulative percentage of material retained on the sieves is calculated and the results are plotted against the representative mesh sizes of the sieves. A series of eight sieves can be used for sediment analysis, with mesh sizes from 1.25 mm to 63 μm or less as shown in Table 2.1(Braja, M.D., 2008).

Table 2.1 Particle size classification

Source: Braja M. Das (2008)

Particle	Particle size	Cohesive properties
Cobble	256-64	Non-cohesive
Gravel	64-2	
Very coarse sand	2-1	Non-cohesive
Coarse sand	1-0.5	
Medium sand	0.5-0.25	
Fine sand	0.125-0.063	
Silt	0.062-0.004	Cohesive sediment
Clay	0.004-0.00024	

Clay particles are plate-like in shape and have a maximum dimension of about 4 µm. Silt particles, like sand, have no characteristic shape the size is between those of clay and sand with diameters ranging from 4 µm to 62 µm. Since the smallest mesh size of commercially available sieves is about 40 µm, the sizes of clay and small silt particles cannot be determined by sieving, and sedimentation techniques are used instead. The sedimentation rate of the particles is measured and their diameter calculated from the semi empirical equation known as Stokes' Law (ISO, 1990).

There is no universally accepted scale for the classification of particles according to their sizes. In North America, the Wentworth Grade Scale is commonly used, elsewhere, the International Grade Scale is preferred. There are minor differences between the two scales and it is, therefore, important to note which scale has been selected and to use it consistently. The boundary between sand and silt (62 µm) separates coarse-grained sediments (sand and larger particles) from fine-grained sediments (silt and clay particles). Coarse-grained sediments are non-cohesive, whereas fine-grained sediments are cohesive, i.e. the particles will stick to one another as well as to other materials. Particle cohesiveness has important chemical and physical implications for sediment quality. Sedimentology and water quality programmes have adopted a convention that considers particulate matter to be larger than 0.45 μm in diameter; anything smaller is considered to be dissolved. This boundary is not entirely valid because clay particles and silt can be much smaller than 0.45 μm. For practical purposes, however, the boundary is convenient, not least because standard membrane filters with 0.45 μm diameter pores can be used to separate suspended particles from dissolved solids (Braja, M.D. 2008).

2.2.6 Composition of Sediment

The amount and nature of suspended load in a water body is affected by the availability of sediment as well as by the turbulent forces in the water. The sand component of the suspended load in a river originates mainly from the river bed. As discharge increases, so do the turbulent forces that cause the sand to be taken into suspension. Sand particles tend to settle quite rapidly because of their shape, density and size. Therefore, the concentration of sand is highest near the bed of a river and lowest near the surface. The curves for medium and coarse sand in Figure 13.1 show this variation of concentration with depth. In lakes, coarser material is deposited rapidly at the point where the river enters the lake and is only resuspended and redeposited under highly turbulent conditions such as generated by high winds (Ongley, 1993).

The bed sediment of a river contributes only a small portion of the clay and silt-sized particles (<62 μm) present in the suspended load. Most of this fine material, which may be 50-100 per cent of the suspended load in many rivers, is eroded and carried to the river by overland flow during rainstorms. This fraction does not easily sink in the water column, and slight turbulent forces keep it in suspension for long periods of time. As a consequence, the silt + clay fraction tends to be fairly evenly distributed throughout the depth of a river as illustrated by the vertical profile for silt + clay. In lakes and reservoirs, fine suspended material originates from river inputs, shoreline and lake bed erosion and organic and inorganic material generated within the lake by biological activity.

In eutrophic waters the latter source can be quite significant. Fine material can be repeatedly resuspended by lake currents (generated by wind stress) until it is eventually deposited in an area where water movements are insufficient to resuspend or remobilise it. Such depositional basins in lakes or reservoirs are important for sediment quality studies because they can indicate the history of anthropogenic influences on the composition of the sediment (Golterman et al, 1983).

2.2.7 Sampling for Sediment

The methods and equipment used for sampling suspended sediment are different from those used for deposited sediments. Also sampling methods for measurements of the quantity of sediment in transport are different than for measurement of sediment quality. The reason for these differences reflects the fact that sediment quantity must include the sand-size fractions which are unequally distributed in depth, whereas sediment quality focuses on the silt + clay fraction which is not depth-dependent (Graf, W.H. 1984).

For bottom sediments it may be necessary to collect deposited sediments with minimum disturbance in order not to lose the fine material on the sediment surface, or because the vertical distribution of the sediment components is important (such as during establishment of historical records or depositional rates). In deep waters this necessitates the use of grabs or corers, but in shallow water a scoop or spatula may be used. Further discussion of the relative merits of different sampling techniques is available in Water Quality Assessments and other relevant publications (Graf, W.H. 1984).

There are four main types of samplers for suspended sediments:

i. Integrated sampler
ii. Instantaneous grab samplers
iii. Pump samplers, and
iv Sedimentation traps

This segregation of material by particle size requires that, for the purposes of measuring quantity of suspended sediment, a depth-integrating sampling technique is used to obtain a sample that accounts for different sediment concentrations throughout the vertical profile of a water body. Many types of sampler have been designed for depth-integrated sampling of suspended sediment. Some are available commercially but are rather expensive. All of them have a number of features in common (Meybeck, M. 1992):

i. Each has a water inlet nozzle and an air outlet. As the water and suspended sediment enter, air is displaced through the air outlet.

ii. Each permits isokinetic sampling. That is, water velocity through the inlet nozzle is equal to the water velocity at the depth of the sampler. This is important for larger particles, such a sand, because the sampler would otherwise tend to over- or under-estimate the amount of suspended sediment. Errors caused by lack of isokinetic sampling are minimal for small particles (< 62 μm) and for practical purposes can be ignore.

iii. The diameter of the water inlet can be selected (or changed) so that the sampler will fill more or less quickly, depending on the depth of the river.

In practice, depth-integrating samplers are lowered to the river bottom, then immediately raised to the surface; lowering and raising should be done at the same rate. The objective is to fill the sampler to about 90 per cent capacity; if the sampler is completely full when it emerges from the water the sample will be biased because the apparatus will have stopped sampling at the point at which it filled up.

2.3 Rainfall

Rainfall is important inputs. Stormwater design deals with rainfall events that can be classified as rainfall intensities and rainfall depth. Rainfall intensities are flow rates. Rainfall depths are volumes. They are used to design detention and retention storage facilities. In most cases, both intensities and volumes are needed to complete a stormwater management plan.

Rainfall can be described according to four characteristics, it is volume, duration, intensity and frequency. All these characteristics are important for defining and understanding rainfall and its effect on hydrologic runoff (Seybert, 2006).

2.3.1 Duration

Duration is the time span over which rainfall occurs for a particular storm event. Duration is often associated with standard storm length specified in a particular hydrologic method. In some method, design storm duration is dictated by the time of concentration of drainage area.

2.3.2 Intensity

Rainfall intensity has the units of velocity. It is the rate at which rainfall fall from the sky. Rainfall volume, intensity is associating the magnitude of surface runoff area. Intensity is expressed in dimensions of length per time, typically the units of inches/hour or cm/hour. However, the rainfall intensity can also be used to determine a volume flow rate because the rainfall is associated with drainage.

2.3.3 Frequency

Rainfall frequency is commonly referred to as storm return period. In statistical analysis, frequency of an event is expressed in term of exceedance probability, which is the probability that the event will be exceeded in a specific time period, the time almost always one year. A sampler will not operate properly if used too large a depth. For example, if the volume of the water –sediment mixture is to be two-thirds of the total container volume for a depth- integrated sample, the sampler should be one-third full as it reaches the bottom of the river, therefore the volume of air in the sampler must be at least two-thirds of the volume (Edward, 1988).

The compression rate, which is related to the compression limit, may restrict the vertical transit rate to less than 0.4 times the mean stream velocity. As the sampler is lowered through the water column, the increased water pressure compresses the air in the sampler. If the sampler is lowered slowly, the incoming water more than takes up the space created by the compression of the air and the excess air and the excess air exists through the exhaust vent. If the sampler is lowered too rapidly, however the incoming water does not compress the air within the sampler fast enough so the pressure on the inside of the sampler is less than the hydrostatic pressure outside the sampler (Edward, 1988).

2.3.4 Volume

The volume of rainfall is commonly provided in inches or centimeters. Volume of rainfall is implied in the depth dimension by associating the magnitude of the drainage area with the rainfall depth. This is why rainfall volume is commonly reported in the unit of acres- inches. For instances if a 14 acre drainage area received 1.7 inches of rainfall, the volume of rainfall will be 14 x 1.7 = 23.8 ac-in.

2.4 Method to Collect Sedimentation Sample

2.4.1 Portable Water Sampler

The environmentally-sealed Portable Water Sampler 6712 controller delivers maximum accuracy and easily handles all of your sampling applications, including: ISCO 6712 Full-size Portable Sampler Versatile and convenient with bottle, ISCO's 6712 Sampler quickly adapt for simple or intricate sampling routines. A convenient drain plug aids removal of water from melted ice. Tough and Reliable The 6712 Portable Sampler features a vacuum- formed ABS plastic shell to withstand exposure and abuse. Its tapered design and trim 20-inch (50.8 cm) diameter result in easy manhole installation and removal. Large, comfortable handles make transporting safe and convenient—even when wearing gloves. ISCO's 6712 Portable Sampler is submersible, watertight, dust-tight, and resistant to sleet and corrosion. Superior capability, rugged construction, and unmatched reliability make the 6712 the ideal choice for portable sampling in just about any application:

i. Wastewater effluent
ii. Stormwater monitoring
iii. CSO monitoring
iv Permit compliance and pretreatment compliance

The 6712's peristaltic pump delivers samples at the EPA-recommended velocity of 2 ft/sec., even at head heights of 26 feet. At a head height of 3 feet, line velocity is 3 ft/sec.

Figure 2.1 Portable Water Sampler

2.4.2 Van Veen Grab Sampler

The Van Veen Grab Sampler is an instrument to sample sediment in water environments. Usually it is a clamshell bucket made out of stainless steel. Up to 20 cm deep samples of roughly 0.1 m2 can be extracted with this instrument. It can be light-weight (roughly 5 kg) and low-tech. The smallest version even fits into hand luggage.

A draw-back of the use of this sampler is that it tends to disturb the sediments more than a box corer does. While letting the instrument down into the water, the two levers with buckets at their ends are spread like an open scissor. The levers are locked in this position, and unlock when hitting the ground. When the rope is pulled upward again, the two buckets close and grab a sample from the sea floor (Rees, (2009).

Figure 2.2 Van Veen Grab

Source: Rees (2009)

2.4.3 Young Grab

The Young Grab, or the Young Modified Van Veen Grab Sampler is an instrument to sample sediment in the ocean. It is a modified version of the Van Veen grab sampler, with a clamshell bucket made out of stainless steel mounted to a supporting frame. The sampling area extracted with this instrument can vary depending on its size. With the modifications this version of the Van Veen grab sampler is heavier than the traditional version. The frame allows for better stability and level sampling. Weights can be attached to the frame to ensure the bucket grabs sufficient sediment, or skids to ensure the gear does not sink too deep in soft sediments (Michael Lane, 2005).

A draw-back of the use of this sampler is that it tends to disturb the sediments more than a box corer does. This does also not allow for sampling of the water column, but only the benthic surface.

While letting the instrument down into the water, the two levers with buckets at their ends are spread like an open scissor. The levers are locked in this position, and unlock when hitting the ground. When the rope is pulled upward again, the two buckets close and grab a sample from the sea floor.

Figure 2.3 Young Grab

Source: Michael Lane (2005)

2.4.4 Peterson Grab

Since 1930, the Petersen grab has been used in fresh water for collecting macroscopic fauna in sand, gravel, marl, or clay and is ideal for comparing data collected by a previous Petersen grab. It is not intended for salt water sampling and must be painted for protection if so used.

Petersen grab has been used in fresh water for collecting macroscopic fauna in sand, gravel, marl, clay or clay combinations. This is a deliberately heavy device for biting deep into hard bottoms and can hold up to 8 removable weights. Vent holes permit water to flow through while the grab is lowered, minimising diagonal movement and reducing the frontal shock wave. Jaws close clamshell- fashion. A safety-pin latch prevents the scoops from closing to help prevent injury. The bayonet-style trip mechanism is designed to release only when the sampler is on the bottom and the cable is slack. Operation requires winch and crane due to the working weight (ENVCO, 2007).

Figure 2.4 Peterson Grab

Source: envcoglobal.com

2.5 Experiment to Test TSS

2.5.1 Total Suspended Solid (TSS)

The principle is well-mixed sample is filtered through a weighed standard glass-fibre filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, it may be necessary to increase the diameter of the filter or decrease the sample volume. To obtain an estimate of total suspended solids, calculate the difference between total dissolved solids and total solids (Nusbaum, I. 1958).

The exclude large floating particles or submerged agglomerates of nonhomogeneous materials from the sample if it is determined that their inclusion is not representative. Because excessive residue on the filter may form a water-entrapping crust, limit the sample size to that yielding no more than 200 mg residue. For samples high in dissolved solids thoroughly wash the filter to ensure removal of dissolved material. Prolonged filtration times resulting from filter clogging may produce high results owing to increased colloidal materials captured on the clogged filter (Nusbaum, I. 1958).

The procedure is pre-prepared glass fibre filter disks are used, eliminate this step. Insert disk with wrinkled side up in filtration apparatus. Apply vacuum and wash disk with three successive 20-mL portions of reagent-grade water. Continue suction to remove all traces of water, turn vacuum off, and discard washings. Remove filter from filtration apparatus and transfer to an inert aluminium weighing dish. If a Gooch crucible is used, remove crucible and filter combination. Dry in an oven at 103 to 105°C for 1 h. If volatile solids are to be measured, ignite at 550°C for 15 min in a muffle furnace. Cool in desiccator to balance temperature and weigh. Repeat cycle of drying or igniting, cooling, desiccating, and weighing until a constant weight is obtained or until weight change is less than 4% of the previous weighing or 0.5 mg, whichever is less. Store in desiccator until needed (Nusbaum, I. 1958).

Selection of filter and sample sizes, choose sample volume to yield between 2.5 and 200 mg dried residue. If volume filtered fails to meet minimum yield, increase sample volume up to 1 L. If complete filtration takes more than 10 min, increase filter diameter or decrease sample volume (Nusbaum, I. 1958).

2.5.2 EPA Method

A well-mixed sample is filtered through a glass fibre filter, and the residue retained on the filter is dried to a constant weight at 103-105^{o}C. This method determines non-filterable residue in drinking, surface, and saline waters; domestic and industrial wastes (Epa.gov, 2009)

(A) Procedure: Filtration apparatus, filter material, pre-washing, post-washing, and drying temperature are specified because these variables have been shown to affect the results.

(B) High Residue Levels: Samples high in Filterable Residue (dissolved solids), such as saline waters, brines and some wastes, may be subject to a positive interference. Filters: Care must be taken in selecting the filtering apparatus so that washing of the filter and any dissolved solids in the filter (7.5) minimizes this potential interference.

Non-representative particulates such as leaves, sticks, fish, and lumps of faecal matter should be excluded from the sample if it is determined that their inclusion is not desired in the final result. Preservation of the sample is not practical; analysis should begin as soon as possible. Refrigeration or icing to 4^{o}C is recommended.

Follow the procedure outlined in EPA method 160.2 for the analysis of samples for TSS. Weigh solid residue to a constant weight, defined as two consecutive weight measurements differing by less than 0.5 mg, or less than 4%, whichever is smaller. Data Calculations and Reporting Units: Calculate the sample results according to Section 8 of EPA Method 160.2.

Report sample results in concentration units of milligram per liter (mg/L) as total suspended solids. Report TSS concentrations that are less than 100 mg/L to 2 significant figures, and TSS concentrations that are greater than or equal to 100 mg/L to 3 significant figures.

For rounding results, adhere to the following rules:

a) If the number following those to be retained is less than 5, round down;

b) If the number following those to be retained is greater than 5, round up; or

c) If the number following the last digit to be retained is equal to 5, round down if the digit is even, or round up if the digit is odd.

All records of analysis and calculations must be legible and sufficient to recalculate all sample concentrations and QC results. Include an example calculation in the data package.

Table 2.2 Summary of Contract Required Detection Limits, Holding Times, and Preservation for Total Suspended Solids (TSS)

Analytical Parameter	**Contract Required Detection Limit (CRDL)**	**Technical and Contract Holding Times**	**Preservation**
Total Suspended Solids (TSS)	10 mg/L	Technical: 7 days from collection; Contract: 5 days from receipt at laboratory	Cool to 4EC ±2EC

2.6 Sample Analysis

Assemble filtering apparatus and filter and begin suction. Wet filter with a small volume of reagent-grade water to seat it. Stir sample with a magnetic stirrer at a speed to shear larger particles, if practical, to obtain a more uniform (preferably homogeneous) particle size. Centrifugal force may separate particles by size and density, resulting in poor precision when point of sample withdrawal is varied. While stirring, pipet a measured volume onto the seated glass-fibre filter. For homogeneous samples, pipet from the approximate midpoint of container but not in vortex. Choose a point both mid depth and midway between wall and vortex. Wash filter with three successive 10-mL volumes of reagent-grade water, allowing complete drainage between washings, and continue suction for about 3 min after filtration is complete. Samples with high dissolved solids may require additional washings (Smith. Greenberg. 1963).

Carefully remove filter from filtration apparatus and transfer to an aluminium weighing dish as a support. Alternatively, remove the crucible and filter combination from the crucible adapter if a Gooch crucible is used. Dry for at least 1 h at 103 to 105°C in an oven, cool in a desiccator to balance temperature at 30 minute and above, and weigh. Repeat the cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until the weight change is less than 4% of the previous weight or 0.5 mg, whichever is less. Analyse at least 10% of all samples in duplicate. Duplicate determinations should agree within 5% of their average weight (Smith, A.L., A.E. Greenberg. 1963).

2.7 Method to Prevent Sedimentation

2.7.1 Sediments Traps

Grassed filter strip (GFS) is one of the sediment trap methods and has a potential practice to control erosion transport. GFS is de- fined as an area of vegetation designed to remove sediment and other pollutants from stormwater runoff by filtration, deposition and infiltration (Deletic and Flectcher, 2006; Liu, 2008). Filter strips are commonly used in an agricultural treatment practice and have a function as buffer zone to protect streams, rivers, creeks or wetlands from sediment particles, nutrients and other chemicals accompanying the stormwater runoff (Mankin, 2007). Modelling based on experimental data has become the basis of knowledge for understanding environmentally significant behaviour and behavioural change in the context of sediment trapped by GFS to protect surface water from suspended solids (SS) and other pollutants associated stormwater coming from construction sites (Deng, 2011; Gumiere, 2011; Hussein, 2007). This approach to the control of non-point sources of pollution is an important part of a broader strategy for the protection of surface water quality in rural and urban areas.

In the previous studies by Deletic (2005), Geza. (2009), and Zanders (2005) have reported that the performance of GFS depends on certain factors of such as soil characteristics, dimension of the GFS, surface runoff, rainfall intensity, slope, ratio of the GFS to construction site and ratio of stormwater elevation to average grass height. The different types of grass have a slight difference in removing of sediment (Liu, 2008). The effectiveness of GFS to retain sediment depends on the GFS dimension and stormwater flow rate (Geza, 2009).

2.7.2 Construction Entrance

Stabilized construction entrances will help you to reduce sediment being carried away by construction vehicles. It is recommended to have two construction entrances, formed regularly by large crushed stone areas. These areas will require maintenance or removing the crushed stone allowing for new and clean stone to replace the sediment-filled previous one. Construction entrance shall be at least 50 feet long. However, in some circumstances this length cannot be achieved, so it is recommended to provide on employee who can pressure-wash the tires of vehicles going in and out of the project (Juan Rodriguez, 2016).

2.7.3 Controlling the Perimeter

An important tip when solving erosion control and sediment problem is to establish and secure a clean perimeter. A clean perimeter will be formed by installing a temporary silt fence barrier properly installed and trenched into the ground providing lateral resistance. This perimeter fence will retain sediment carried by storm-water, only in small areas and will be useless on large areas or high slopes. Do not use silt fencing or fibre rolls alone in areas that drain more than a quarter-acre per 100 feet of fence (Juan Rodriguez, 2016).

2.7.4 Storm Inlet Protection

Usually storm inlets are protected inside a project but, not so frequent on adjacent or nearby storm drain inlets. Providing protection against erosion and sediment control on a storm drain inlet can be achieved by using silt fence, rock-filled bags, or block and gravel. The type of measure used will depend on the type of drain inlet being protected, its opening and the flow that it is expected to receive (Juan Rodriguez, 2016).

2.7.5 Slope Protection

There are multiple options for erosion and sediment control on slopes. Slope erosion control methods will depend on the degree of inclination of the slope being worked out. On a moderate slope active measures such as silt fence or fibre rolls can be installed on levelled contours between 10 or 20 feet in distance. Geo-textiles, turf blanket and mats can also be used as slope protection (Juan Rodriguez, 2016).

2.7.6 Minimize Disturbed Area

When starting your construction project, control the limits of your project by working only in the necessary areas involved in the site. Controlling the areas to be worked is a great tip and will reduce significantly the erosion and sediment control problems. Keep natural vegetation when possible and do not disturb areas that have topsoil in place (Juan Rodriguez, 2016).

2.7.7 Stabilize Soil

Many permits require you to carry out stabilization measures in place after a specific time frame. Some temporary measures can include: seeding, mulch, blankets, and the use of wool binders. If the stabilization measure is permanent it can vary from permanent seeding, planting, channel stabilization and green buffer. After the permanent stabilization measure is in place, you can go to your SWPPP to mark the area as completed and stop inspections in that area. Remember that dust control is also another area that needs to be stabilized (Juan Rodriguez, 2016).

2.8 First-flush for Indicator Bacteria and TSS

In the United States Environmental Protection Agency’s (USEPA) National Water Quality Inventory in 2006, 12% of stream and river miles were impaired by indicator bacteria (USEPA 2008). Stormwater runoff has been identified as a contributor to indicator bacteria in surface waters. However, despite concerns over water quality degradation due to indicator bacteria in stormwater runoff, numerous facets of microbial transport and fate are poorly understood. Pollutants in stormwater runoff are sometimes thought to exhibit a “first flush” transport pattern. Essentially, that a larger proportion of pollutant mass or higher pollutant concentrations are expected during the initial stages of a storm event (Sansalone and Cristina 2004). First flush patterns have been evaluated in urban stormwater runoff for multiple pollutants including sediments, oil and grease, metals, nutrients, chemical oxygen demand, pH, temperature, and conductivity (Flint and Davis 2007).

Recent studies by McCarthy (2009) provided de- tailed analysis of the first flush for E. coli in four urban watersheds in Melbourne, Australia. McCarthy (2009) showed a consistent first flush was not present for any of the four watersheds; however, a first flush effect was statistically identified in the medium density residential watershed. Further, McCarthy (2009) tested associations between the first flush strength and antecedent climate parameters, storm characteristics, and flow characteristics.. It should be noted that the weather patterns in Melbourne, Australia, differ from those in the South eastern United States, potentially leading to differences in microbial behaviour. Differences in weather include higher average yearly rainfall, higher average summer temperatures, and lower average winter temperatures in Raleigh, NC (ABOM 2010; SCONC 2009).

CHAPTER 3

METHODOLOGY

3.1 Introduction

The study methodology includes the steps involved in this study from the beginning until the final stage in order to achieve study aim and objectives. The planning of the methodology had been carried out systematically. Some of the stages involved in this study are including feasibility study, sampling, laboratory testing and data analysis. The summary of the research methodology is shown in Figure 3.1. The methodology is briefly described in the following part.

This study starts by selecting a topic which is suitable to do research which give benefits to the society. The topic is discussed with the supervisor in order to get an idea and planning to achieve study aim and objectives more smoothly. All the data analysis and sample of the study are collected with the specific equipment that is used for this study. The samples that are collected are brought to the laboratory to do experiment. The results of the study are collected for research purpose.

3.2 Flow Chart of the Study

Figure 3.1 shown the flow chart of study from identify the topic, completing proposal, installation of equipment, collection data, result, analysis, conclusion and recommendations.

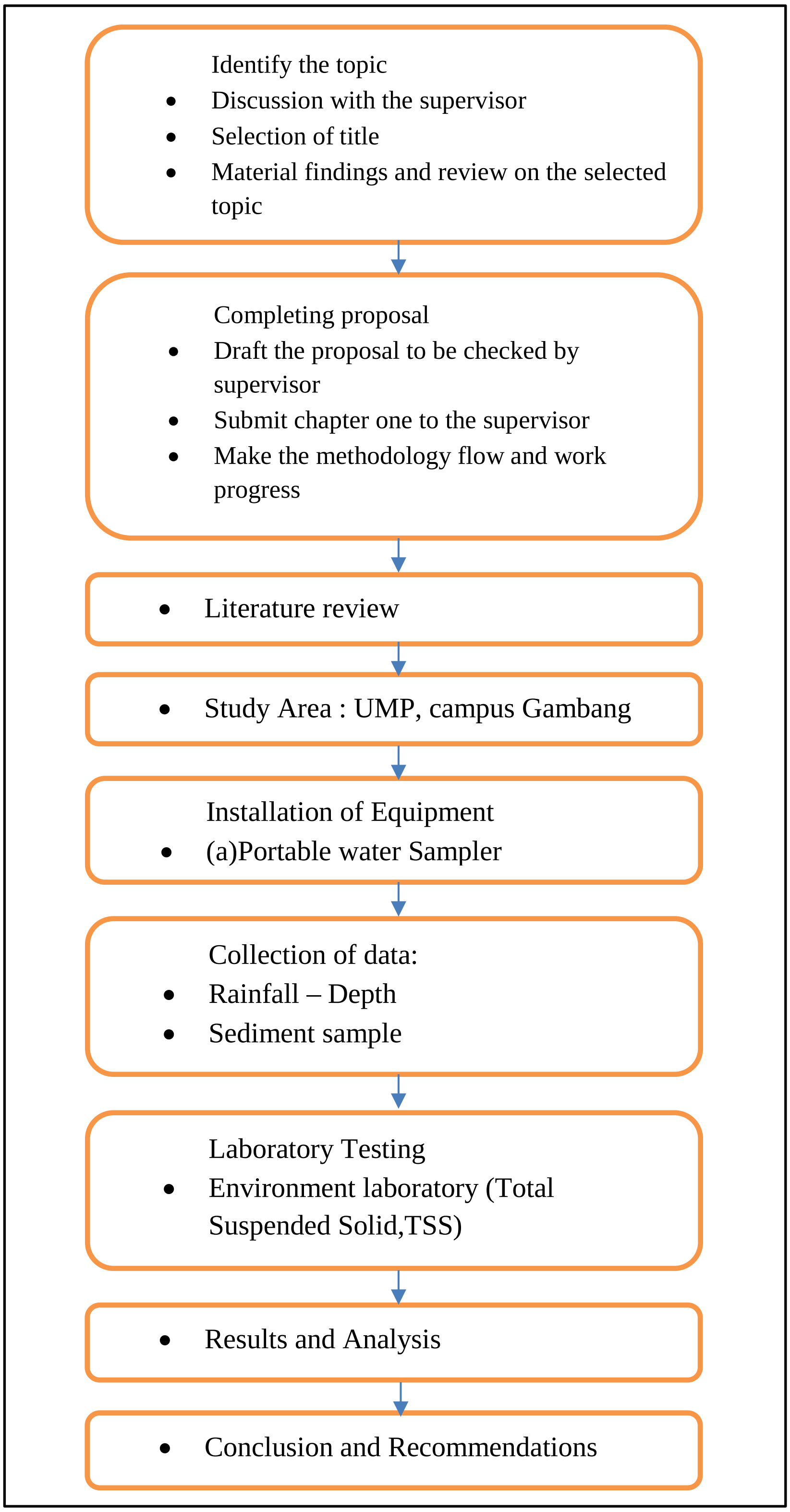


Figure 3.1 Flow Chart of Study

3.3 Study Area

The campus is currently operating in an industrial estate about 30 km from the city of Kuantan and it is a 2 and a half hours' drive from Kuala Lumpur, via the East Coast Expressway. The area of campus Gambang is 126 acre squares which can accommodate 5,000 students. Strategically located in the East Coast Industrial Belt of Peninsular Malaysia which hosts a number of multinational corporations (MNCs) in the chemical, petro-chemical, manufacturing, automotive and biotechnology industries, UMP students have been exposed extensively to the latest development in the fields of engineering and technology.

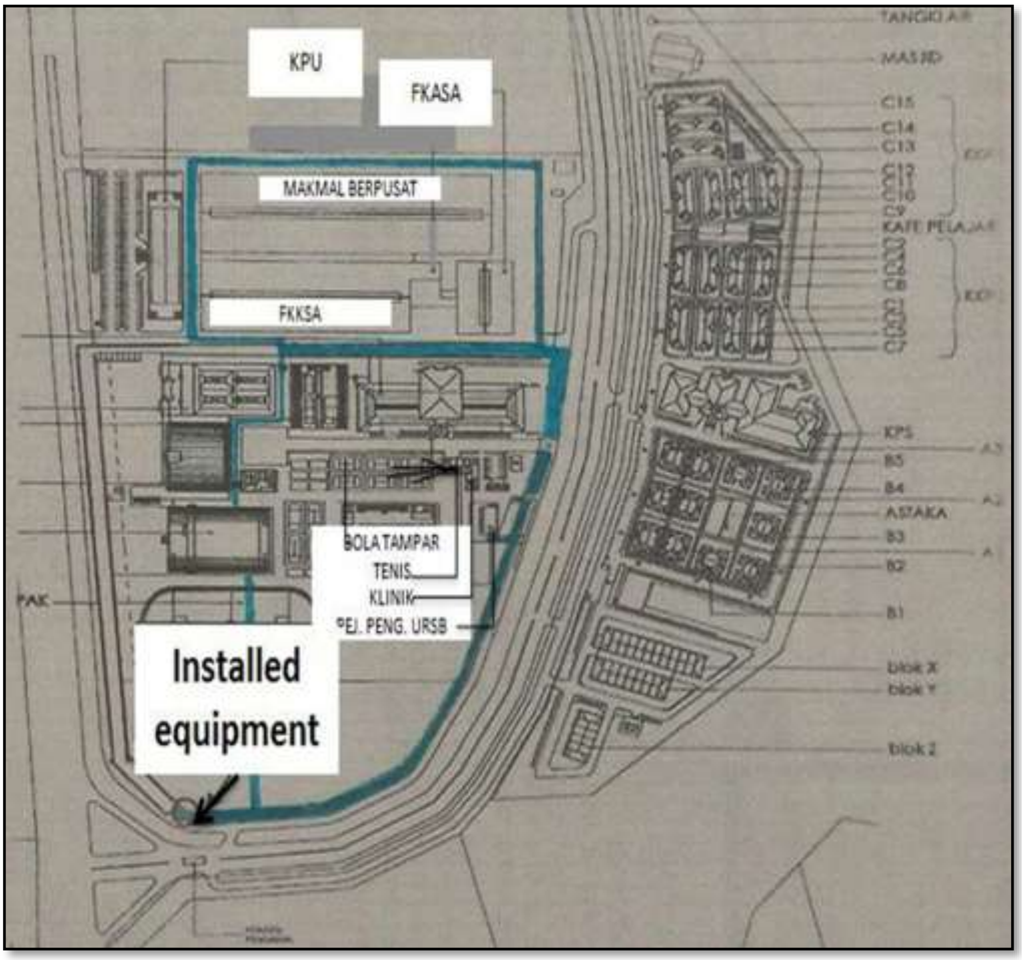


Figure 3.2 Study Area

Source: UMP Plan

Figure 3.3 UMP Location

Source: https://www.google.com/earth

3.4 Equipment

The equipment was placed at the safe place and far from structure and tree at the outlet of UMP drainage system to ensure any effects caused are minimized. The equipment are rain gauge and portable water sampler. The data was collected from equipment.

3.4.1 Portable Water Sampler

The sedimentation equipment used are the 6712 Full-Size Portable Sampler in Figure3.3. The data was read at reading sample in Figure 3.4. The suction of water sample occurs through the suction tube to the sampling bottle Figure 3.5. The water level for suction to occur can be set in the sampler. All of this equipment needs the maintenance to make sure it functioning well. This is important to get the best data.

Figure 3.4 Portable Water Sampler

Figure 3.5 Reading of Sampler

Figure 3.6 Sampling Bottles

3.5 Data Collection

Data collection carried out is to achieve purpose of objective it is to collect and analyse the rainfall pattern in UMP Gambang campus, and the last is to develop relationship between rainfall intensity and TSS. Data collection start in December 2017 and finish in March 2018.

3.5.1 Rainfall Depth

Rainfall depth data are collected from a rain gauge in Ump Gambang Campus. The duration of the rainfall data is 15 minutes and the data are collected from December 2017 until March 2018.

For rainfall, equipment used is ISCO 674 Rain Gauge it is gather and measure the amount of rainfall over a set period of time. When connected to a flow meter, the rain gauge enables the flow meter to store rainfall data in memory which then can be download. The Rain Gauge was set to record the data for every 15 minutes and it was placed at the safe place and far from structure and tree at the outlet of UMP drainage system to ensure any effects caused are minimized. Most rain gauges generally measure the rainfall in millimetres.

3.5.2 Sediment Sample

The soil sample was taken at site and was test at Environment laboratory to weight the sediment. The Total Suspended Solid (TSS) was conducted, the sample was test follow the rainfall event. The sediment through filter paper and weighted using analytical balance. The total sample for this study is 47 sample of sediment and a total of 8 events from December 2107 until March 2018.

3.5.3 Water Level

The water level detected by liquid presence detectors which will then will be recorded in the device. The level recorded every 5 minutes.

3.5.4 Flow Rate

From the water level, runoff can be obtained using Manning Equation.

$$Q = \frac{1}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}} \qquad 3.1$$

Where:

Q = flow rate of runoff

n = Manning coefficient

A = Area of cross section

R = Hydraulic Radius (A/P)

S = Slope

P = Wetted perimeter

3.5.5 Total Suspended Solid (TSS)

The data of sedimentation was taken using the Portable Sampler in the outlet drainage. The suction of water sampler through the suction tube to the sampling bottle occurs during storm. The suctions only occur when the water level reach the required level that was set in the sampler. The sample then brought to Environmental Laboratory.

3.6 Laboratory

The data collection for sedimentation consists of recording the water sampling. During the data collection the photographic record of the samples in the bottles was made. The sample from the bottles were collected after heavy storm and brought to Universiti Malaysia Pahang Environmental Laboratory. The sample is analysed based on Total Suspended Solid.

3.6.1 Environmental Laboratory

Total Suspended Solids are solid materials it is including organic and inorganic, that are suspended in the water. These would include silt, plankton and industrial wastes. Water quality decrease to absorb light due to suspended solid high density. Waters then become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life. The cause aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced. The combination of warmer water, less light and less oxygen makes it impossible for some forms of life to exist. Suspended solids affect life in other ways. They can reduce growth rates, decrease resistance to disease. Suspended solids can result from erosion from urban runoff and agricultural land, industrial wastes, bank erosion, bottom feeders (such as carp), algae growth or wastewater discharges. The method is:

1. Preparation of the glass fibre filter disc: The filter disc is inserted onto the base and the funnel is clamped on. The disc is washed three times with 20mL distilled water while vacuum is applied. All traces of water are removed by continuous application of vacuum after water has passed through. The funnel is removed from the base and filter is placed in the aluminium dish and dried in an oven at 103°C to 105°C for one hour. The dish was removed from the oven, desiccated and weighed.

2. A sample volume (max 200 mL) that will yield not more than 200 mg of total suspended solid was selected.

3. The filter is placed on the base and the funnel is clamped on, then vacuum is applied. The filter is wetted with a small volume of distilled water to seal the filter against the base.

4. The sample is shaken vigorously and 100 mL of sample is transferred to the filter using a large orifice, volumetric pipette. All traces of water is removed by continuously applying vacuum after the sample has passed through.

5. The sample is shaken vigorously and 100 mL of sample is transferred to the filter using a large orifice, volumetric pipette. All traces of water is removed by continuously applying vacuum after the sample has passed through.

6. The disc filter is carefully removed from the base. It is then dried for at least 1 hour at 103°C to 105°C. Then the filter is cooled in a desiccator and weighed.

3.6.2 Apparatus

The apparatus used to test the Total Suspended Solid (TSS) were glass microfiber filter disc, 5.5 m type GF/C (0.7 µm) in Figure 3.6. Disposable aluminium dishes used to put the dish on the experiment performed as in figure 3.7. The suction flask size 47 mm is glass microanalysis filter holder (funnel, clamp and base) in Figure 3.8. Oven used to dry operation filter disc at 130^{o}C to 105^{o}C in Figure 3.10. The filter disc placed in desiccator for cool up at 30 minute as in Figure 3.11. Analytic balance to weighing to 0.1 mg in Figure 3.12. The distilled water used to clean the filter disc in Figure 3.13. Meanwhile, volumetric flask (1000 ml) used to measure the distilled water and water sampler as in Figure 3.14. Reagents was collected at site to test Total Suspended Solid (TSS).

Figure 3.7 Glass Microfiber Filter Disc

Figure 3.8 Disposable Aluminium Dishes

Figure 3.9 Suction Flask

Figure 3.10 Oven

Figure 3.11 Desiccator

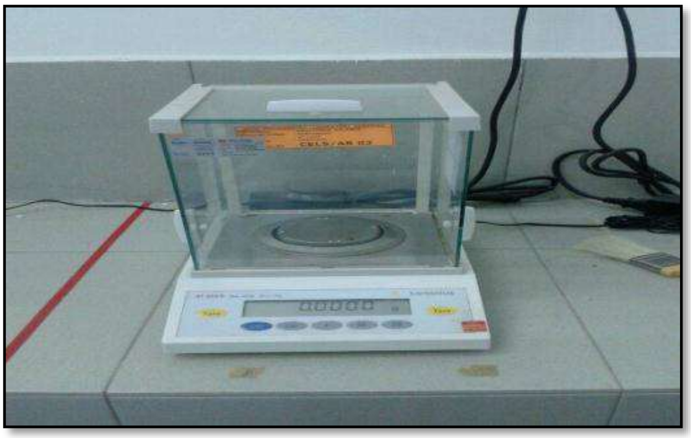


Figure 3.12 Analytical Balance

Figure 3.13 Distilled Water

Figure 3.14 Volumetric Flask

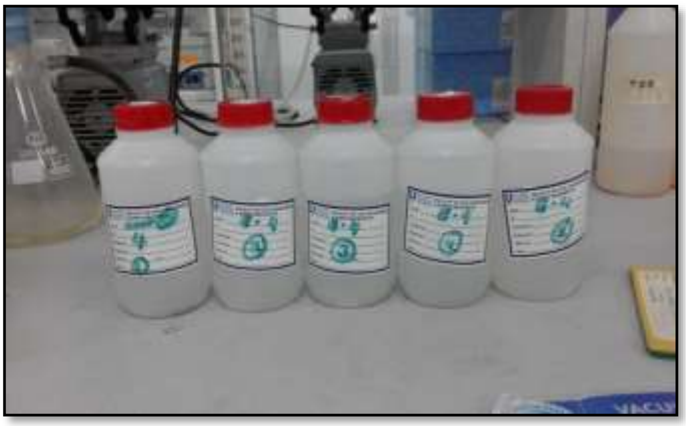


Figure 3.15 Reagent (Sample)

3.6.3 Calculation of TSS

$$TSS = \frac{(A-B)}{Volume} \qquad 3.2$$

Where:

A = weight of filter + dried residue, mg

B = weight of filter, mg.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

It has been described in details about the method to collect and analyse the data previous chapter. In this chapter, the results and observation that has been collected were discussed and explained clearly. For every spot that the observation is done, the graph of the observation was included and the results were discussed.

The data was collected in December 2017 until March 2018 and those data was included in the analysis. Laboratory test done to obtain relevant data for fulfilling the objectives of the study. The data were analysed to obtain the conclusion of the study.

4.2 Data Collection

4.2.1 Rainfall Data

This rainfall data was collected from the rainfall gauge in UMP Gambang area. This data show the depth of the rain in millimetre in UMP area and the date when it’s raining in the area. This data was collected from December 2017 until March 2018.

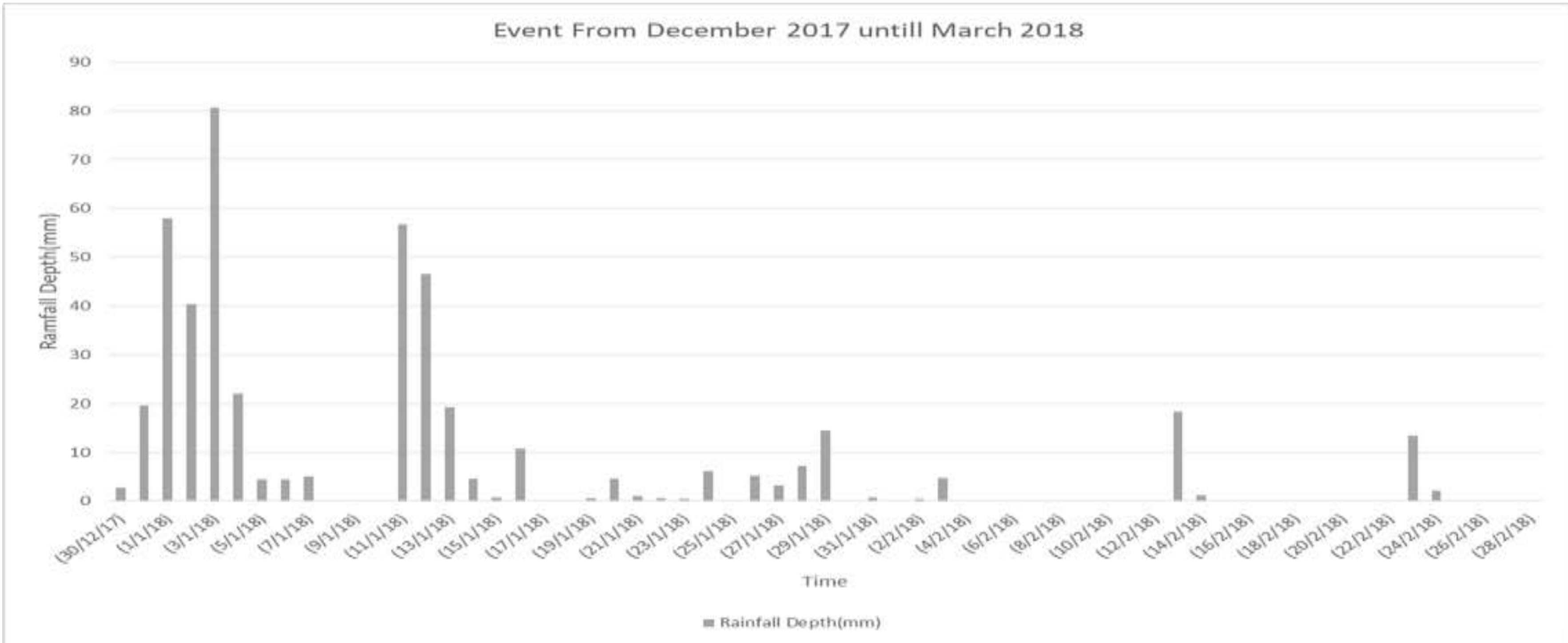


Figure 4.1 Rainfall Data (December 2017 – March 2018)

4.2.2 Flow Rate

From the water level, runoff can be obtained using Manning Equation such as in Equation 3.1. The data to calculate flow rate are shown in Table 4.1.

Table 4.1 Data for Flow Rate Calculation

Area (m)	**Manning Coefficient**	**Wetted perimeter (m)**	**Hydraulic radius, R**	**Slope , S**	**Flowrate, Q (m3/s)**
0.03	0.015	0.7	0.04	0.001	0.001

$Q = 1/0.015\ (0.03)(0.04^{2/3})(0.001^{1/2})$

$Q = 0.001\ m^3/s$

4.2.3 Rating Curve

This curve is used to determine the value of flowrate by knowing the value of the water level. The water level must be in the range of the graph as in Figure 4.2

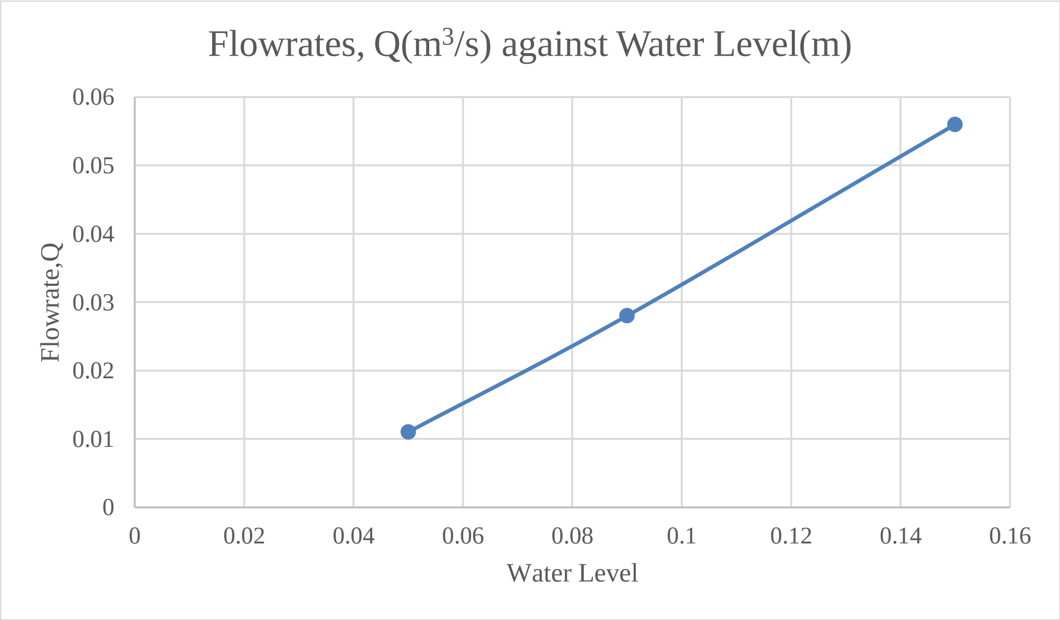


Figure 4.2 Rating Curve

4.2.4 Total Suspended Solid (TSS)

The data for the calculation of Total Suspended Solid (TSS) are shown in Table 4.2. The TSS value was calculated by using Equation 3.2

Table 4.2 Data for TSS Calculation

	Sample 1	**Sample 2**	**Sample 3**
Weight of filter and dish, mg (B)	18.6373	18.4776	16.6353
Weight of filter and dish + residue, mg (A)	18.6508	18.5130	16.6474
Volume of sample filtered, mL (C)	200	200	200
Total Suspended Solid, mg/L	298	149.5	54

$$TSS = \frac{(18.6508 - 18.6373\ )}{200}$$

TSS = 298mg/L

4.3 Data Analysis

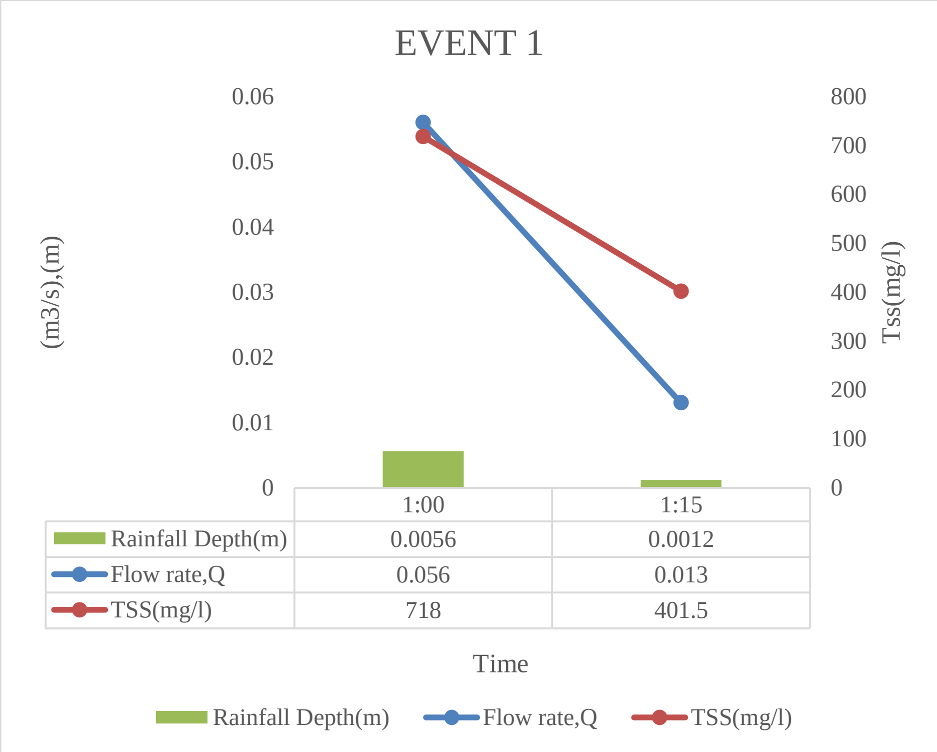
Analysis was done from the data gathered. The analysis involved are the rainfall depth and Total Suspended Solid (TSS) from September until November 2016. Table 4.1 shown the 14 events and duration of rainfall.

Table 4.3 Rainfall Event and Total Rain

EVENT	DATE	TOTAL RAIN(mm)
1	30/12/2017	6.8
2	7/1/2018	4.4
3	11/1/2018	9
4	16/1/2018	4.6
5	24/1/2018	5.8
6	28/1/2018	6.6
7	3/2/2018	8.0
8	23/2/2018	3.4

4.3.1 Event on 30 December 2017

Figure 4.3 shows the Event 1 on 30 December 2017. It can be seen that the rainfall starts at 1.00 am the first flush 718 mg/L it is the higher Total Suspended Solid (TSS) in Event 1 with 5.6 mm in rainfall depth and a flowrate of 0.056 m^3/s. Then rainfall depth was decrease 1.2 mm with TSS is 401.5 mg/L at 1.15 am and a flowrate of 0.013 m^3/s. The first flush of this event is higher than the second flush. The flowrate decrease from $0.056m^3/s$ to $0.013m^3/s$ when the rainfall depth decrease. This is because after 1:15 am, the rain starts to stop raining and the intensity of the rain decrease. The TSS value of this event are compared to the next event to get the relationship between TSS value and the period of rainless day.



	1:00	1:15
Rainfall Depth(m)	0.0056	0.0012
Flow rate,Q	0.056	0.013
TSS(mg/l)	718	401.5

Figure 4.3 Rainfall Depth and TSS on 30 December 2017 (Event 1)

4.3.2 Event on 7 January 2018

As in Figure 4.4 after 7 days rainless the first flush Total Suspended Solid (TSS) on 7 January 2018 is 903 mg/L with 3.4 mm rainfall depth and a flowrate of 0.022 m^3/s. In second period at 17:00 pm, TSS is 535 mg/L with 1 mm and a flowrate of 0.012 m^3/s. The flowrate decrease as the rainfall depth decrease because after 17:00 pm, the intensity of rain decreases and it's not rain heavily after 17:00 pm. Furthermore, after the 7 days rainless the TSS was dramatically increase from last period in Event 1 on 30 December 2018. The rainless days also affect the value of TSS. The longer the period of rainless day, which is 7 days, the higher the value of Total Suspended Solid. The TSS value of this event are compared with the next event.

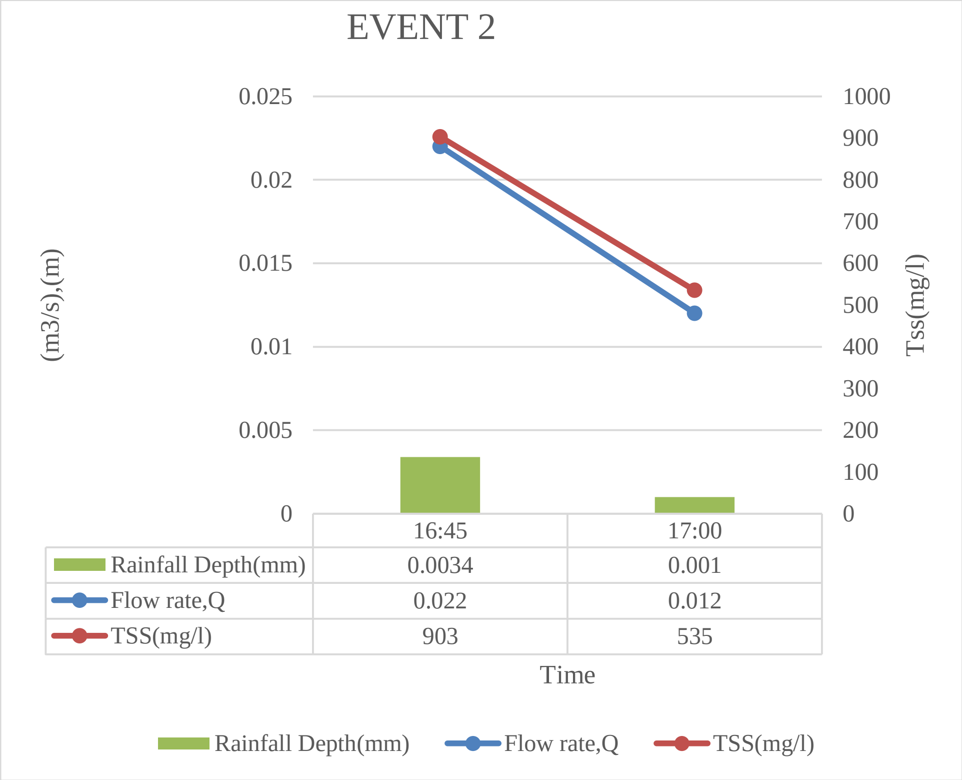


Figure 4.4 Rainfall Depth and TSS on 7 January 2018 (Event 2)

4.3.3 Event on 11 January 2018

Figure 4.5 shown Event 3 on 11 January 2018. It can be seen the first flush dramatically decrease after the last flush in event two on 7 January 2018. It Total Suspended Solid (TSS) value is 345 mg/L with 1 mm in rainfall depth and a flowrate of 0.012m^3/s which is lesser then the last flush in event two. Then at 9:45 am rainfall depth was increase, it is 2.4 mm with TSS is 231 mg/L and a flowrate of 0.024m^3/s, at 10:00 am rainfall depth was slightly increase, it is 5 mm with TSS is 205.5 mg/L and a flowrate of 0.05m^3/s. TSS was decrease after rainless, it was compare after event on 7 January 2018 last flush is 436 mg/L, while after 3 days rainless TSS was dramatically decrease to 90.5 mg/L. The value of the first flush is higher than the second flush and the third flush. This show that the first flush always carries a high number of sediment in a drainage system. The value of flowrate also increases within time, this is because on this day, it was raining heavily and the rain still not stop after 10:00 am.

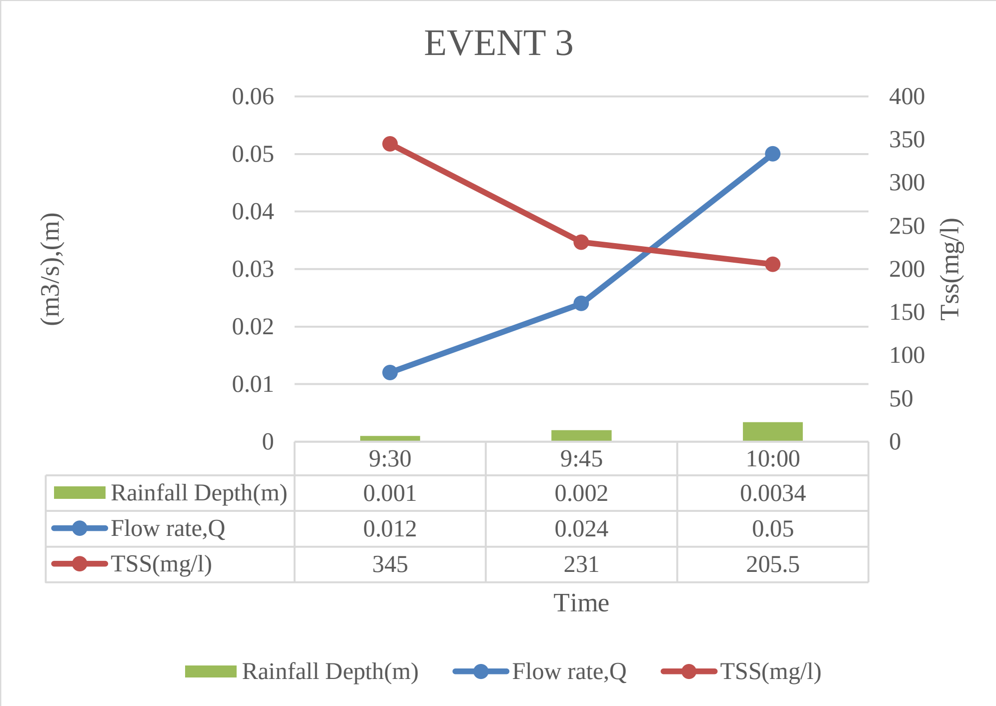


Figure 4.5 Rainfall Depth and TSS on 11 January 2018 (Event 3)

4.3.4 Event on 16 January 2018

Event 4 on 16 January 2018 in Figure 4.6, first flush Total Suspended Solid (TSS) is 506 mg/L with 3.6 mm rainfall depth at 16:15 pm. The flowrate at 16:15 pm is 0.022m^3/s. TSS was decreased at 16:30 pm which is 238 mg/L with 1 mm and a flowrate of 0.011m^3/s. The graph shows TSS was continuously decrease. Furthermore, after the 5 days rainless the TSS was dramatically increase from last period in Event 3 on 11 January 2018. The rainless days also affect the value of TSS. The TSS value for the first flush is higher than the second flush which is 506 mg/L to 238 mg/L. The flowrate also starts to decrease with the decrease of the rainfall depth. Its starts to rain heavily in UMP around 16:15 pm and start to slowly stop around 17:00 pm.

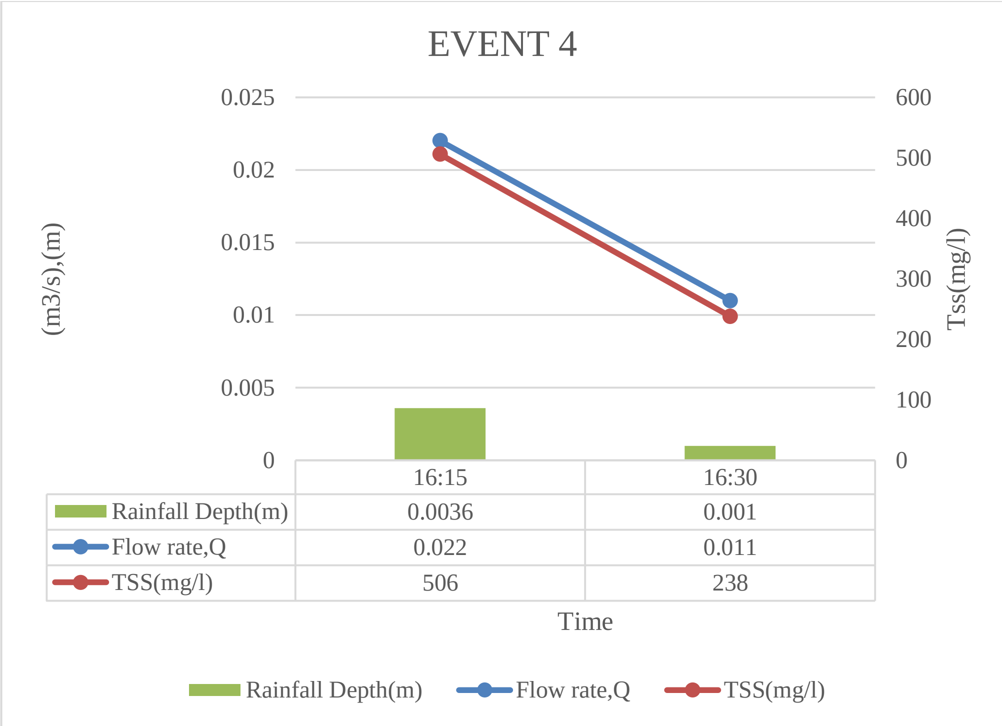


Figure 4.6 Rainfall Depth and TSS on 16 January 2018 (Event 4)

4.3.5 Event on 24 January 2018

Figure 4.7 shows the Event 5 on 24 January 2018. It can be seen that the rainfall starts at 16:30 pm the TSS is 905 mg/L with 5.4 mm in rainfall depth and a flowrate of 0.036 m^3/s. Then rainfall depth was decrease 0.4 mm with TSS is 600 mg/L at 16:45 pm and a flowrate of 0.017 m^3/s. After the 7 days rainless the TSS was dramatically increase from last period in Event 4 on 16 January 2018. The rainless days increase the value of TSS. The first flush value of TSS for this event is higher than the second flush value of TSS which prove that the sediment in the first flush always higher than the second flush. The rainfall depth also decreases within time and the flowrate of water also decrease within time.

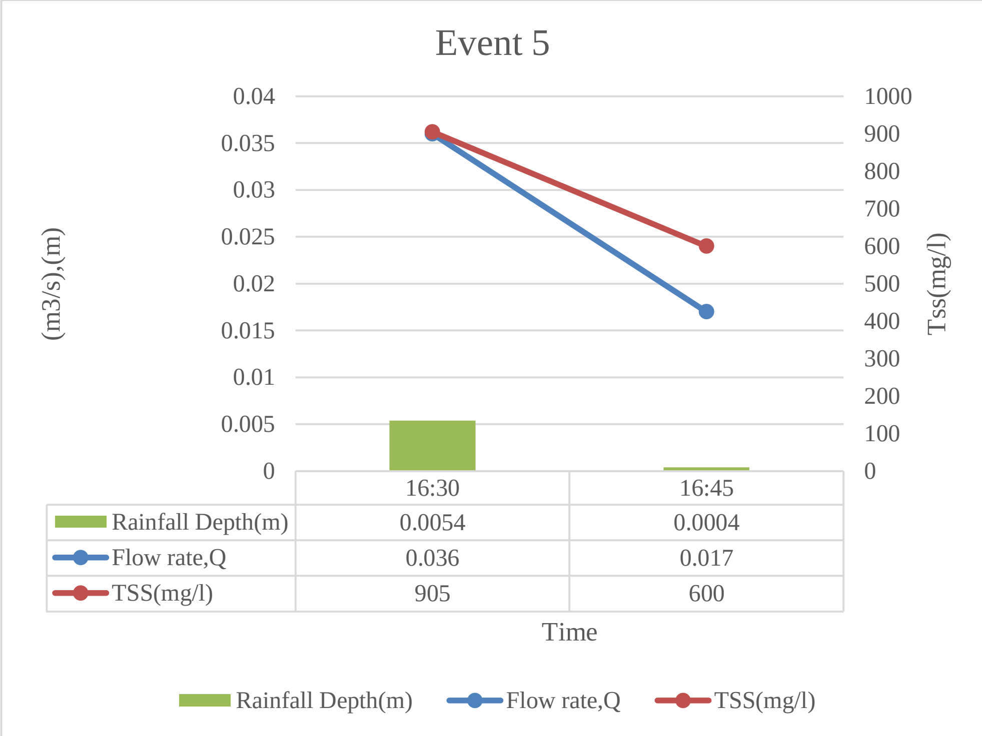


Figure 4.7 Rainfall Depth and TSS on 24 January 2018 (Event 5)

4.3.6 Event on 28 January 2018

Figure 4.8 shows the Event 6 on 28 January 2018. It can be seen that the rainfall starts at 16:00 pm the TSS is 478 mg/L with 2.8 mm in rainfall depth and a flowrate of 0.016 m^3/s. Then rainfall depth was decrease 2.2 mm with TSS is 216.5 mg/L at 16:45 pm and a flowrate of 0.017m^3/s. At 17:00 pm, the TSS is 80.5 mg/l and the rainfall depth is 1.6mm with flowrate of 0.0164 m^3/s. After the 3 days rainless the TSS was dramatically decreases from last period in Event 5 on 24 January 2018. The short period of rainless days decreases the value of TSS. The first flush value of TSS for this event is higher than the second flush value of TSS and the third flush which prove that the sediment in the first flush always higher than the second flush and the third flush. The rainfall depth also decreases within time and the flowrate of water are almost constant within time. The flowrate almost constant maybe because the intensity of rain is slightly different from 16:00 pm until 17:00 pm.

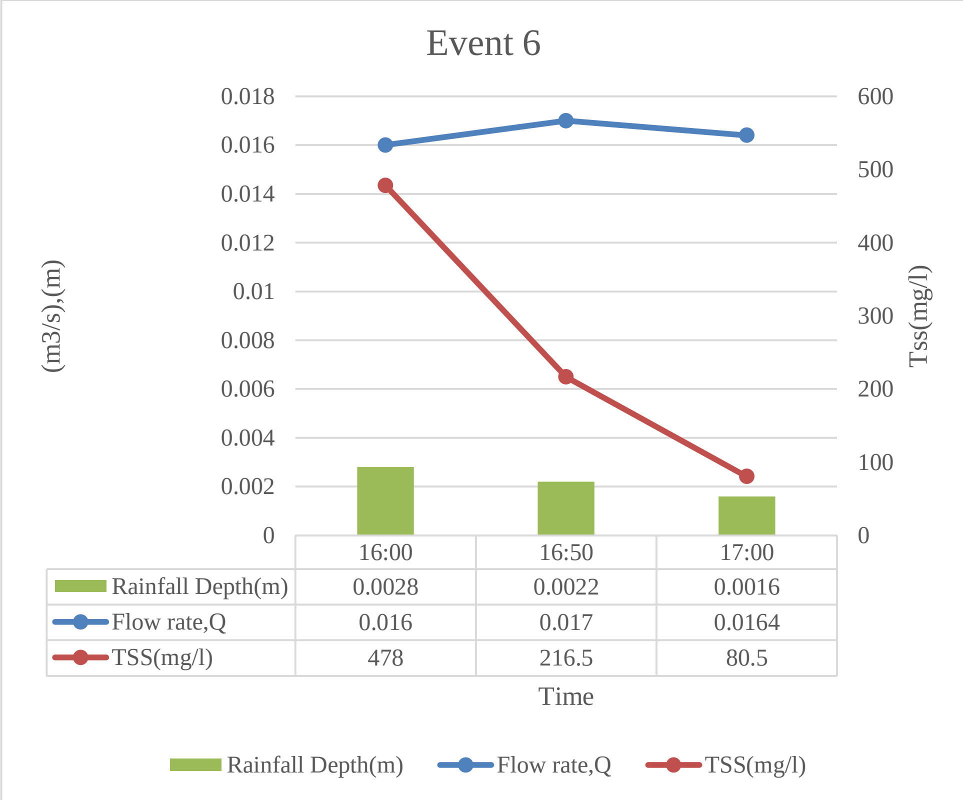


Figure 4.8 Rainfall Depth and TSS on 28 January 2018 (Event 6)

4.3.7 Event on 3 February 2108

Figure 4.9 shows the Event 7 on 3 February 2018. It can be seen that the rainfall starts at 16:45 pm the TSS is 298 mg/L with 2.2 mm in rainfall depth and a flowrate of 0.051 m^3/s. Then rainfall depth was increase 5.8 mm with TSS of 203.5 mg/L at 17:00 pm and a flowrate of 0.073 m^3/s. After the 2 days rainless the TSS was dramatically decreases from last period in Event 6 on 28 January 2018. The short period of rainless days decreases the value of TSS. The first flush value of TSS for this event is higher than the second flush value of TSS which prove that the sediment in the first flush always higher than the second flush. The rainfall depth also increases within time and the flowrate of water are also increase within time. The flowrate increases maybe because the intensity of rain is high from 16:45 pm until 17:00 pm and it is still rain heavily after 17:00 pm.

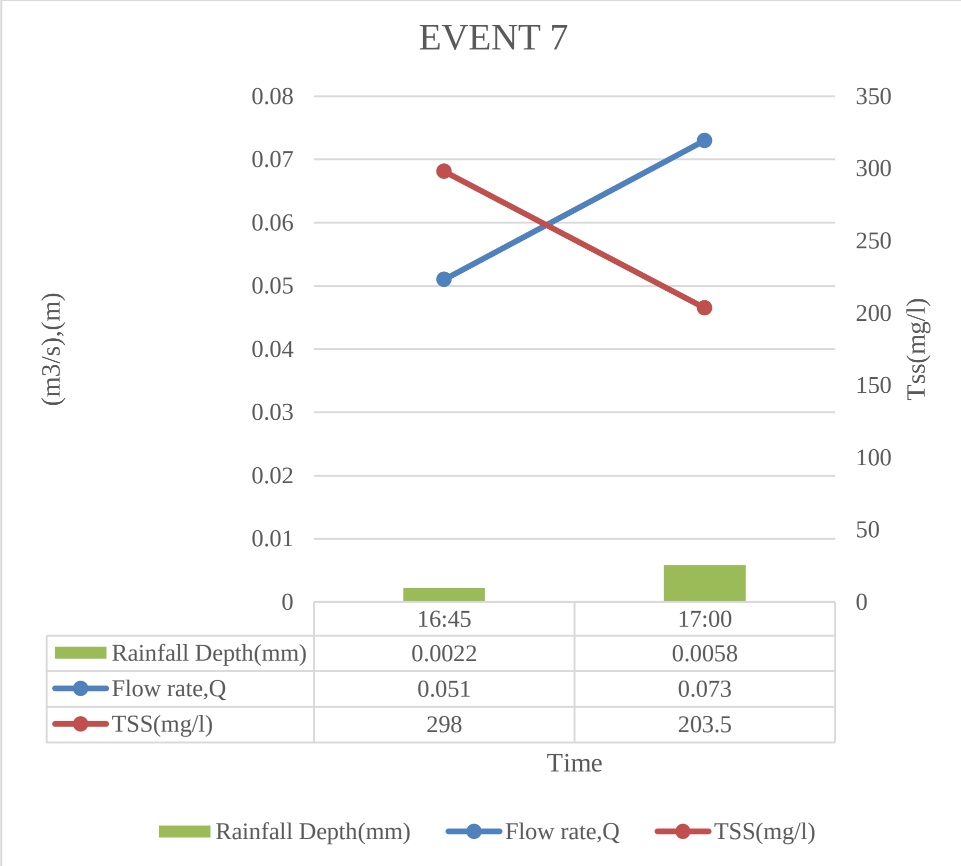


Figure 4.9 Rainfall Depth and TSS on 3 February 2018 (Event 7)

4.3.8 Event on 23 February 2018

Figure 4.10 shown Event 8 on 23 February 2018. It can be seen the first flush dramatically increase after the last flush in event 7 on 3 February 2018. It Total Suspended Solid (TSS) value is 1068 mg/L with 1.2 mm in rainfall depth and a flowrate of 0.0155m^3/s which is higher than the last flush in event 7. Then at 23:15 pm rainfall depth was decrease, it is 1.0 mm with TSS is 806 mg/L and a flowrate of 0.015m^3/s, at 23:30 pm rainfall depth was slightly increase, it is 1.2 mm with TSS is 486 mg/L and a flowrate of 0.0153m^3/s. TSS was increase after rainless day, it was compare after event on 3 February 2018 last flush is 298 mg/L, while after 20 days rainless TSS was dramatically increase to 1068 mg/L. The longer period of rainless days increases the value of TSS. The first flush value of TSS for this event is higher than the second flush value of TSS and the third flush which prove that the sediment in the first flush always higher than the second flush and the third flush. The rainfall depth has slight difference within time and the flowrate of water are almost constant within time. The flowrate almost constant maybe because the intensity of rain are slightly different from 23:00 pm until 23:30 pm.

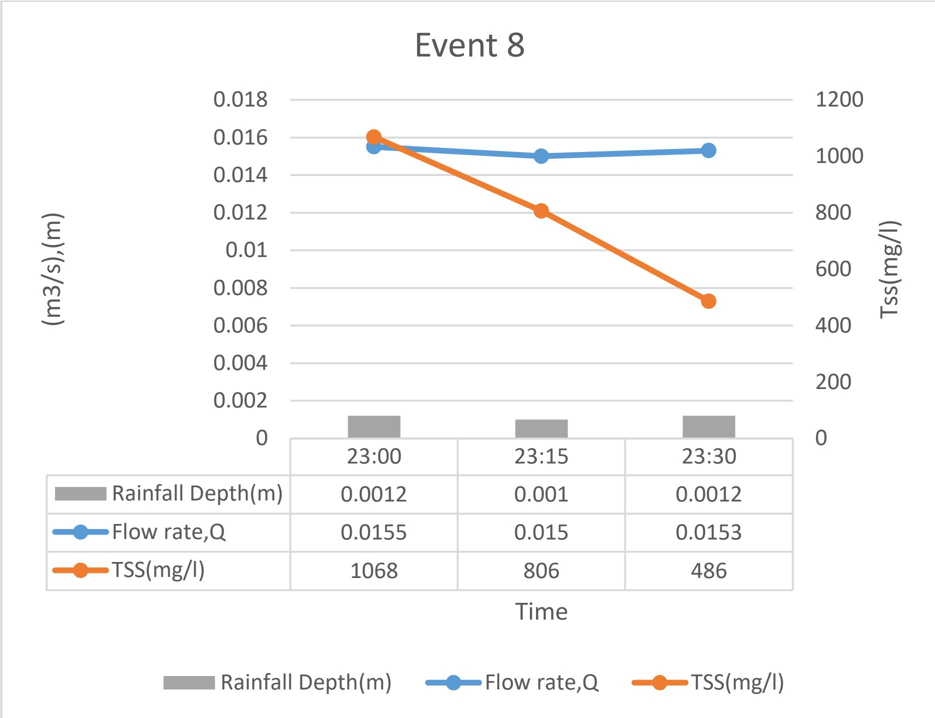


Figure 4.10 Rainfall Depth and TSS on 23 February 2018 (Event 8)

4.3.9 Summary of All Event

For Event 1 on 30 December 2017. It can be seen that the value of the TSS for the first flush 718 mg/L in Figure 4.3. It is the higher Total Suspended Solid (TSS) in Event 1 with 5.6 mm in rainfall depth. The TSS value of this event are compared to the next event to get the relationship between TSS value and the period of rainless day. After 7 days rainless, the first flush Total Suspended Solid (TSS) on 7 January 2018 is 903 mg/L with 3.4 mm rainfall depth in Figure 4.4. For Event 3 on 11 January 2018 in Figure 4.5, it can be seen the first flush dramatically decrease after the last flush in event two on 7 January 2018. It Total Suspended Solid (TSS) value is 345 mg/L with 1 mm in rainfall depth. Event 4 on 16 January 2018, first flush Total Suspended Solid (TSS) is 506 mg/L with 3.6 mm rainfall depth at 16:15 pm as shown in Figure 4.6. Furthermore, after the 5 days rainless the TSS was dramatically increase from last period in Event 3 on 11 January 2018. In Event 5 on 24 January 2018, it can be seen that the TSS is 905 mg/L with 5.4 mm in rainfall depth as shown in Figure 4.7. After the 7 days rainless the TSS was dramatically increase from last period in Event 4 on 16

January 2018. In Figure 4.8 which is Event 6 on 28 January 2018, it shows that the value of the TSS is 478 mg/L with 2.8 mm in rainfall depth. In Figure 4.9, it can be seen the TSS is 298 mg/L with 2.2 mm in rainfall depth in the Event 7 on 3 February 2018. After the 2 days rainless the TSS was dramatically decreases from last period in Event 6 on 28 January 2018. On 23 February 2018 which is Event 8, it can be seen the first flush dramatically increase after the last flush in event 7 on 3 February 2018. It Total Suspended Solid (TSS) value is 1068 mg/L with 1.2 mm in rainfall depth in Figure 4.10 which is higher than the last flush in event 7.

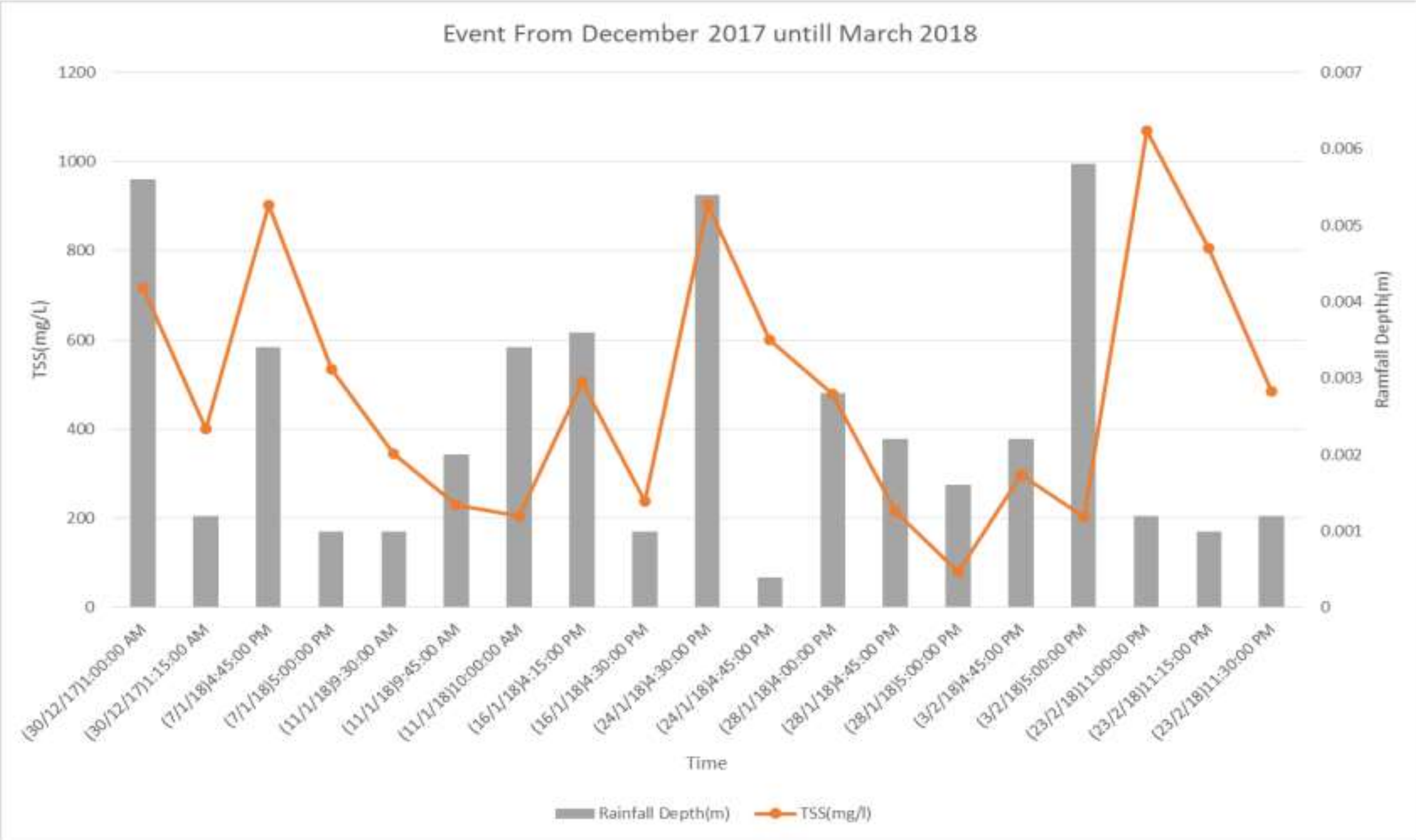


Figure 4.11 Summary of All Event (December 2017 – March 2018

CHAPTER 5

CONCLUSION

5.1 Introduction

The data have been collected started December 2017 until March 2018. During the study period it can be concluded from the calculation and analysis that the Total Suspended Solid (TSS) that occurs affected by rainfall depth and rainless rainfall period.

It also concluded that the appropriate measure for the sedimentation data is Total Suspended Solid (TSS) as it is empirically on of the best indicator of the sediment delivery into drainage system or watercourse from the land during land clearance and earthwork activities.

5.2 Conclusion

The value of TSS was high in UMP Gambang. This is because the construction work ongoing in UMP Gambang which was the construction of new building besides the Pusat Kesihatan Ump. The value of TSS always high in construction area because the water flow contains high sediment.

From the results, we can conclude that when the period of rainless day was longer, the TSS value will be high. This was because when there is a period of rainless day, the sediment will be accumulated in the catchment area. For example, in the streets, field and construction site. When its rain, the water will wash the sediment which was accumulated and the water will flow into the drainage system, this make the value of TSS high in Universiti Malaysia Pahang in Gambang which was from the results of this study.

5.3 Recommendation

For future research of this kind of study there are few recommendations that can be taken into consideration such as ensuring that future development continues in an environmentally sound manner.

i. The length time for doing this research must be lengthening more. The suitable duration for doing this research is a year. The studies of sedimentation take some time for at least a year for the accurate data of sediments.
ii. Water level is the detected by liquid presence detectors which will then be recorded in the device, the level is recorded every five minutes important for this study. From the water level, runoff can be obtained using the Manning equation it can determine the volume flow rate because the rainfall is associated with drainage.
iii. The laboratory test result accuracy could be increased by avoiding errors during application of the test. The lack of experience while conducting the laboratory test, wrong way of reading and recording data, and errors in calculation are the most frequent errors. These can be avoided by learning the method of the testing properly, practice the procedures and repeat the test to get the reliable data.
iv. Sediment basin can be installed in construction site to reduce the water pollution. It can capture eroded or disturbed soil that is washed off during rain storms, and protect the water quality of a nearby stream, river, lake, or bay. A research about the effectiveness of sediment basin can be conducted to see whether the TSS value will decrease or increase after sediment basin are implemented in construction site.
v. A sediment trap also can be implement in UMP because it can reduce the quantity of sediment flow in the drainage system. A research about relationship between TSS value and sedimentation can be conducted to get the results.

REFERENCES

ISO (1990), International Organization for Standardization, Geneva : Graphical Presentation. International Standard ISO 9276- *Results of Particle Size Analysis*. Part 1

Graf, W.H. (1984). Graw-Hill, New York Mc: *Hydraulics of Sediment Transport.* Meybeck, M. (1992), World Health Organization, Geneva : Monitoring of particulate matter quality, (3rd ed)

*Nusbaum, I. (1958). New method for determination of suspended solids: Sewage Ind Wastes.*Vol. 10 pp. 30

Trees, C.C. (1978). J. Water Pollut. Control Fed: Analytical analysis of the effect of dissolved solids on suspended solids determination. pp.2370.

Golterman, H.L., Sly, P.G. and Thomas, R.L. (1983*) Study of the Relationships Between Water Quality and Sediment Transport.* Technical Papers in Hydrology No. 26.

Jamie Bartram and Richard Ballance Water Quality Monitoring (1996)- *A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes.* Vol. 18, No. 2, pp. 161-172

Smith, A.L. & A.E. Greenberg. (1963). Water Pollut. Control Fed :*Evaluation of methods for determining suspended solids in wastewater.* No. 35, pp. 940.

Ongley, E.D. (1992). Environmental quality: Changing times for sediment programs*, Erosion and Sediment Transport Monitoring Programmes in River Basins*. No. 21, pp.379-390.

Ongley, E.D., Yuzyk, T.R. and Krishnappan, B.G. (1990). *Vertical and lateral distribution of fine grained particles in prairie and cordilleran rivers*. Vol 24, No. 3, pp. 303-312.

ISO (1990), International Organization for Standardization, Geneva : Graphical Presentation. International Standard ISO 9276- *Results of*

Particle Size Analysis. Part 1

Braja, M.D. (2008). *Advanced Soils Mecanics*. (3rd ed) Taylor & Francis, New York.

Ongley, E.D. (1993). Global water pollution: Challenges And Opportunities

Bogen, J. Wlling, D. E and Day. T. (1992*), Erosion and Sediment Transport Monitoring*

Urban Stromwater Management Manual for Malaysia (2000) *: Construction Sediment* BMPs. Vol. 15

Robin G.Mclnnes and Jenny Jakeways (2002), *Instability Planning and Management Seeking Sustainable Solutions to Ground Movements Problems*

Deletic, A., Flectcher, T.D. (2006). *Performance of grass filters used for stormwater treatment – a field and modelling study*. Journal of Hydrology 317, 261–275.

Dong, L.X., Guan, W.B., Chen, Q., Li, X.H., Liu, X.H., Zeng, X.M., (2011). *Sediment transport in the Yellow Sea and East China Sea. Estuarine, Coastal and Shelf Science* 93, 248–258.

Liu, X., Zhang, X., Zhang, M., (2008). *Major factors influencing the effiencacy of vegetated buffers on sediment particles trapping: a review and analysis*. Journal of Environmental Quality 37, 1667–1674.

Deletic, A. (2005). *Sediment transport in urban runoff over grassed areas*. Journal of Hydrology 301, 108–122.

The Institution of Engineering Singapore (2004), *Legislation & Regulation on Erosion and Sediment Control at Construction Site*

Deletic, A. (2005). *Sediment transport in urban runoff over grassed areas.* Journal of Hydrology 301, 108–122.

Mankin, K.R., Ngandu, D.M., Barden, C.J., Hutchinson, S.L., Geyer, W.A., (2007). *Grass-shrub riparian buffer removal of sediment particles, phosphorus and nitrogenfrom simulated runoff*. Journal of the American Water Resources Association 43, 1108–1116.

Geza, M., Barfield, B.J., Huhnke, R.L., Stoecker, A., Storm, D.E., Stevens, E.W., (2009). *Comparison of targeted replacement and vegetative filter strip for sediment particles control and cost effectiveness*. Journal of Water Resources Planning and Management 135, 406–409.

Gumiere, S.J., Le Bissonnais, Y., Raclot, D., Cheviron, B., (2011). *Vegetated filter effects on sediment particlesological connectivity of agricultural catchments in erosion modelling: a review*. Earth Surface Processes and Landforms 36, 3–19.

Hussein, J., Ghadiri, H., Yu, B., Rose, C.(2007). *Sediment particles retention by a stiff grass hedge under subcritical flow conditions*. Soil Science Society of America Journal 71, 1516–1523.

Australian Bureau of Meteorology (ABOM). (2010). *Climate statistics for Australian locations: summary statistics for Melbourne regional office*. http://www.bom.gov.au/climate/ averages/tables/cw_086071.shtml (February 16, 2010).

McCarthy, D. T. (2008). *Modelling microorganisms in urban stormwater*. Doctoral dissertation, Monash University, Melbourne, Australia.

State Climate Office of North Carolina (SCONC). (2009). 1971–2000 Climate Normals.http://www.nc-climate.ncsu. edu/cronos/normals.php?station=317079 (Nov. 18, 2009).

United States Environmental Protection Agency (USEPA). (2008). *Water quality assessment and total maximum daily loads information* (ATTAINS).

Sansalone, J. J., & Cristina, C. M. (2004). *First flush concepts for suspended and dissolved solids in small impervious watersheds*. Journal of Environmental Engineering, 130 (11), 1301–1314.

Michael Lane (2005). *Side-by-Side Comparison of Young Grab and Composite Petite Ponar Grab Samples for the Calculation of the Benthic Index of Biological Integrity* (B-IBI)

Rees (2009): *Guidelines for the study of the epibenthos of subtidal environments; Copenhagen: International Council of the Exploration of the Sea* (ICES Techniques in Marine Environmental Sciences 42) - 90 p.

APPENDIX A

Results of Total Suspended Solid

Event on 30 December 2017

Table A.1 Sample Data for Event 1

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of filter and dish, mg (B)	16.740	18.6472	18.4774	16.6353	22.1803
Weight of filter and dish + residue, mg (A)	16.7913	18.6955	18.5214	16.6764	22.2196
Volume of sample filtered, mL (C)	200	200	200	200	200
Total Suspended Solid, mg/L	256.5	241.5	220	205.5	196.5

Event on 7 January 2018

Table A.2 Sample Data for Event 2

	Sample 1	Sample 2	Sample 3
Weight of filter and dish, mg (B)	59.7033	59.5178	59.8194
Weight of filter and dish + residue, mg (A)	59.8839	59.6248	59.9066
Volume of sample filtered, mL (C)	200	200	200
Total Suspended Solid, mg/L	903	535	436

Event on 11 January 2018

Table A.3 Sample Data for Event 3

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Weight of filter and dish, mg (B)	22.7447	22.1785	16.6307	18.6451	16.7406	18.4775
Weight of filter and dish + residue, mg (A)	22.7815	22.2107	16.6588	18.6703	16.7587	18.4934
Volume of sample filtered, mL (C)	200	200	200	200	200	200
Total Suspended Solid, mg/L	184	161	140.5	126	90.5	79.5

Event on 16 January 2018

Table A.4 Sample Data for Event 4

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Weight of filter and dish, mg (B)	59.5201	59.7023	59.8166	57.1594	59.9452	56.3461
Weight of filter and dish + residue, mg (A)	59.5575	59.7380	59.8447	57.1810	59.9622	56.3570
Volume of sample filtered, mL (C)	200	200	200	200	200	200
Total Suspended Solid, mg/L	187	178.5	140.5	108	85	54.5

Event on 24 January 2018

Table A.5 Sample Data for Event 5

	Sample 1	Sample 2	Sample 3
Weight of filter and dish, mg (B)	59.7023	59.5200	59.8194
Weight of filter and dish + residue, mg (A)	59.8833	59.6400	59.9070
Volume of sample filtered, mL (C)	200	200	200
Total Suspended Solid, mg/L	905	600	438

Event on 28 January 2018

Table A.6 Sample Data for Event 6

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Weight of filter and dish, mg (B)	16.7401	16.3070	18.6460	18.4780	22.1780	22.7447
Weight of filter and dish + residue, mg (A)	16.7749	16.3390	18.6740	18.5020	22.1965	22.7608
Volume of sample filtered, mL (C)	200	200	200	200	200	200
Total Suspended Solid, mg/L	174	160	144.5	124	92.5	80.5

Event on 3 February 2018

Table A.7 Sample Data for Event 7

	Sample 1	Sample 2	Sample 3
Weight of filter and dish, mg (B)	18.6373	18.4776	16.6353
Weight of filter and dish + residue, mg (A)	18.6508	18.5130	16.6474
Volume of sample filtered, mL (C)	200	200	200
Total Suspended Solid, mg/L	298	149.5	54

Event on 23 February 2018

Table A.8 Sample Data for Event 8

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of filter and dish, mg (B)	59.7023	16.3070	18.6460	18.4780	22.1796
Weight of filter and dish + residue, mg (A)	58.8867	16.4220	18.6740	18.5020	22.1965
Volume of sample filtered, mL (C)	200	200	200	200	200
Total Suspended Solid, mg/L	1068	503	303	274	212