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Electrochemical Assessment of Water Quality as an Effect of Construction

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Providing controlling system to drain effluent from the construction site is crucial and should be implemented to any construction project. The system should be tested in order to certify its effectiveness. Failure or inefficient system will affect the water quality at the catchment area, which then will convey to the source point such as lake and drainage.This study was done in the campus of Universiti Kebangsaan Malaysia (UKM), which located within the Bangi Reserved Forest. There were few development in the campus involved the construction of new buildings for the needs of the university. In this study area, the locations of the new constructions arewithinthe water sourcepoint. The research using grab samples to assess the water quality parameters such as pH, Total Suspended Solid (TSS), turbidity, Biological Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD). The results of parameters for water quality obtained are compared to the phases or activities at construction, to determine the specific time and type of the activities that contributed to the indication of water quality. In this study, the parameters obtained indicate that water quality around the lake and monsoon drain was affected by the constructions surrounding area. Most of the parameters were within the permitted limit when there were no construction activities, while the decreasing of water quality was when the construction activities being started especially on Phase 2 and 3. This study also shows the significant results of water quality with rainfall. The increasing of water quality parameters was found when there was rainfall on the day of sampling. Even there are no rainfall event on the sampling day, the parameters value obtained were influenced by the rainfall event occur prior days before the sampling day.

Keywords: Water quality; construction; rainfall

1. INTRODUCTION

Construction is believed to be one of the factors affecting water quality surrounding its site including river, lakes or streams. This will leads to the disturbance of water resources quality for normal daily use, or for aquatic life. Therefore, observation of water quality is essential from pre-construction, active construction, and post-construction to examine the actual reasons on this matter.

In Malaysia, it is estimated that the demands of water will be increased based on the growth of populations and economic development. The water demand is projected to be increased by 60% and 113% from 1995 to 2010, and 2020 respectively [2]. Therefore, there is a need to control and maintain the quantities of raw water, with an adequate quality to ensure the safe of available water. As a developing country, Malaysia is experienced economic development that leads to expanding of its urban development. These urban development especially construction is assumed to be one of the major contribution to the poor water quality.

According to the Houser and Pruess [4], construction site is one of the largest contributions to the sediment loading of the surface water as large amount of land have been disturbed. Construction without sediment erosion control structures can cause high sediment load and degradation to the water quality. It is due to the runoff from construction site which transmit pollution to wetland, ponds, lake, stream, and rivers [1]. This issue is explained by USEPA (2005) and Koukal et al. [5], which concluded that the sedimentation problem leads the dislocated of particle, then, cloud the water that restricting the penetration of sunlight, hence, limiting the process that depend on light and trigger problem to the aquatic life. Sediment will provide surface for the growth of microorganisms, absorb chemical, and also experience abnormal temperature fluctuation [3].Other than that, development such as highways and building will increase the amount of impervious surface, which runoff the pollutant that potentially drained in the water bodies and cause mutilation.

Risk triggered by hazardous substances especially in aquatic ecosystem should be minimized by introducing implementation of monitoring and remedial programs. Storm water pollution controller to control sediment loads is one of the remedial programs that are necessary for a construction site. A study was done by US geological survey to investigate the effectiveness of storm water pollution controls at residential construction sites. The results show the decreasing of total and suspended solids loads for between the pre-construction and active construction phase, and also between the active construction and post construction phase [4]. This shows that the remedial program on construction site does gives positive affect to the water quality.

Some studies and researches have been conducted to confirm then impact of construction to the water quality. A study was conducted by US Geological Survey to the three stages of construction; pre-construction, active construction, and post-construction for both rural and urban land [4]. This study found that sediments level during the active construction is higher than the pre and post construction. The result also shows that the uncontrolled constructions site that did not employ any sediment control will leads to the higher potential of erosion and sediment loading than the non-land disturbing activities.

Beside the issues of construction being harmful to the aquatic live and cause poor water quality, some studies shows the reverse effect. A study of reconstruction of two tunnels for highway at the Great Smoky Mountains was done to monitor the impacts of sediment and acid generating geology. The study was done in three phases, which are before, during and after the construction. The results which are based on the pH and suspended solid shows that there was no statically impact on the stream [3].

Another study was done by Houser and Pruess [4] at Abram Creek to observe water quality impacts of a construction project which involve the placement of culvert for the creek. This project was allowing for the construction of a runway at an airport in Cleveland, Ohio. The parameters obtained indicated that water quality were found to be statistically insignificant because there was only small differences on the results obtained for the upstream and downstream of the creek.

Based on the literature that concern of water quality that affected by construction, this study was conducted to observed water quality of lakes and stream in Malaysia started at UKM reserved forest. There are few constructions in progress within the campus. The primary objective of this study is to evaluate the water quality effect for monsoon drain and lake at UKM campus due to the construction at its surrounding area. The study was conducted in three phases; pre-construction, active constructions, and post-construction. Parameters obtained for water quality indication will be compared with these phases. Other than that, parameters obtained also will be compared to the rainfall event at the construction sites.

2. PROJECT SITE

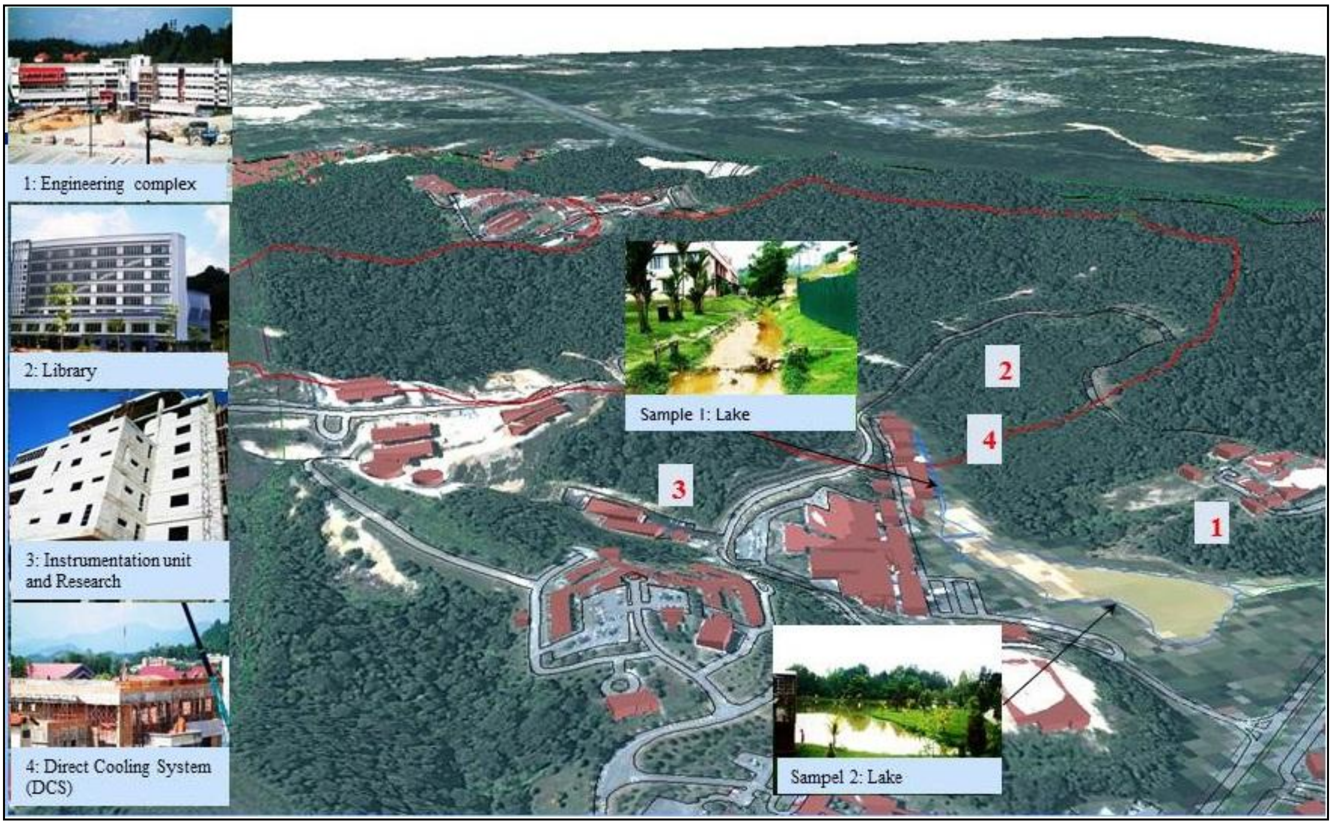

Figure 1. Locations of constructions in progress

UKM campus is located within Bangi Forest Reserved area. These 100 hectares forest is consists of lakes, swamps, and trekkers facilities. Part of the forest area is selected to be the research plot of the study. Several construction activities are in progress in the study area. The constructions are including Engineering Complex, Library, Instrumentation Unit and Research Centre, Direct Cooling System (DCS). The construction period for each building is from July 14, 2009 until July 14, 2011; April 30, 2009 until November 12, 2011, and July 26, 2010 until August 25, 2011 for Engineering Complex, Instrumentation Unit and Research Centre, and Direct Cooling System (DCS) respectively. It is noted that the construction activities detail for Library cannot be obtained. The locations of the buildings mentioned above are as shown in Figure 1.

3. MATERIAL AND METHOD

3.1 Water quality Assessment

For the determination of the water quality in the study area, samples were collected at two identified locations. The grab samples were taken at UKM Lake, and the monsoon drain. The monsoon drain is located between the existing and new engineering faculty complexes. The locations of the samples taken are as shown in *Figure 1*. The fluctuation of the water constituents for water quality is normally in term of physical, chemical, and biological [7]. Therefore, in this study, five parameters were determined for the water quality indicator. The parameters are pH, turbidity, $BOD_{5,}$ COD and TSS. All tests for the parameters were carried out in the environmental lab, Department of Civil Engineering, UKM. It is noted that the water quality in this study is based on the Type IIA Interim National Water Quality Standard for Malaysia (INWQS), which is suitable for water supply with conventional treatment required, and sensitive aquatic species.

3.1.1 pH

pH assessment in this research was using pH 300/310 hand-held meter by Eutech Instruments Pte Ltd/Oakton Instruments (*Figure 2*). This waterproof instrument is a microprocessor-based which is capable to measure pH, mV and temperature. The battery operated meter is comprises of a temperature probes, and two electrode holders. The meter uses any standard pH electrodes which the probes are slide over the BNC connector socket on the meter. The electrodes are stored in the buffer solution (pH 4.01 or 7). To measure the pH, the electrodes are dipped into the calibration buffer, and then the electrode is rinsed with de-ionized water or rinse solution. The probe shall not be wiped to avoid electrostatic charge existence on the glass surface. Then, the electrodes are immersed into the sample, and stirred to achieve homogeneous sample. Finally, reading of pH will be appeared on the LCD display after read button is pressed.

Figure 2. pH 300/310 meter

3.1.2 Turbidity

In this study, turbidity of samples was assessed by the value of Nephelometric Turbidity Unit (NTU). The value is obtained by 2100P Portable TurbidimeterHach Model (*Figure 3*), that operates on the nephelometric principle of turbidity measurement. The reading is in the range of 0 to 1000 NTU with automatic point placement or manual range selection of 0-9.99, 0 – 99.9 and 0-1000 NTU. The meter that includes a tungsten-filamen lamp, a 90° detector to monitor scattered light and a transmitted light detector, operates through ratio optical system. The ratio of the signals from the 90° and transmitted light detectors is calculated from the meter microprocessor of the instrument. This technique will corrects for interferences from colour or light absorbing materials, and compensate for fluctuations in lamp intensity, and providing long-term calibration stability. This system is also designed to minimize stray light, and increasing the accuracy of data given.

Figure 3. 2100P Portable Turbidimeter

To measure turbidity, 1.5 ml of sample needs to be filled in a container provided by the manufacturer. A thin film needs to be applied to the container which has been wiped in order to remove water spots and fingerprints. After turning on the meter, insert the sample in the instrument cell and press the RANGE key. The instrument will automatically display AUTO RNG indicated the status of the instrument is in automatic range selection. Then select SIGNAL AVERAGE which the instrument is using signal averaging. Finally, press the READ button, and the NTU reading for the sample is appeared on the display screen.

3.1.3 Biochemical Oxygen Demand (BOD_5)

Obtaining the amount of 5-days BODinvolved several procedures.First, reagents need to be prepared such as phosphate buffer solution, magnesium sulphate solution, calcium chloride solution, and ferric chloride solution. Then, all prepared reagents are diluted with dilution water with the ratio of 1:100 for sample and water. After that, the dilutedsample was divided and filled into 5 BOD bottles. Initial reading of dissolve oxygen (DO) is determined from the first bottle, while others are tightly close with the stopper, and incubate for 5 days at 20^{o}C.Reading of DO for the remaining bottles is checked every day until day 5. For the controlling purposes, 5 days of DO reading should be done for dilution water which is consider as blank sample. Therefore, reading of the blank samples will be compared to the real samples accordingly.

The DO is measured using microprocessor based Model 5000 Dissolved Oxygen Meter by YSI incorporated (*Figure 4*). This instrument has internal memory for 100 data points with auto stabilization features which gives stable reading of DO. The oxygen using this meter can be measured in the range of 0.0 to 60.0 mg/L. The instrument is used with YSI 5010 BOD Probe, which is a polarographic dissolved oxygen sensor. The probe is comprises of electrolytic cell which has anode and cathode portion that are covered by oxygen membrane covers. The electrode covers is used as a transmission barrier to avoid cathode surface from being polluted due to the impurities of thesurroundings.

Figure 4. Model 5000 Dissolved Oxygen Meter

To start measure the DO reading, the probe should be connected to the instrument. Then, remove the cap and immerse the tip of the probe in the sample. Movement of sample will leads to the higher accuracy of oxygen measurement. Therefore, the sample needs to be stirred to at least 10 seconds. Stirring can be done by pressing the magnetic stirrer attached to the probe and the velocity movement can be controlled. After stirring is done, the reading is displayed on the screen.

Other than that, this instrument can also measure sample temperature with the sensor that placed on the electrode.The reading of temperature obtained is the compensating reading with the barometric pressure measurement from the built-in barometer.

3.1.4 Chemical Oxygen Demand (COD)

Obtaining the amount of COD is starting with the preparation of reagents such as potassium dichromate solution, sulphuric acid, phenanthroline indicator solution, standard ferrous sulphate (FAS) titrant, and mercuric sulphate. First, mercuric sulphate solution is diluted with the sample in a flask, and potassium dichromate solution was added while stirring the sample. Then, sulphuric acid reagent is added into the flask, and the mixture is reflux for 2 hours in the reflux apparatus (*Figure 5*). Next, stop the reflux apparatus, and let the mixture cool down in room temperature. Titration process is takes place by titrating FAS into the flask while stirring the mixture. The mixture will turn to blue-green colour at the beginning and changed to the reddish brown. Titrating of FAS process needs to be stopped when the colour of the mixture changed to reddish brown. Then, check the volume of FAS that titrated into the mixture. Repeat the same procedure of refluxing and titrating of blank distilled water containing the same reagents and volume that equal to the sample. The COD value can be obtained using the formula.

Figure 5. Reflux apparatus

3.2.5 Total Suspended Solid (TSS)

TSS is measured by defining the volume of sample before and after the filtration process through filtration apparatus. First, measure the weight of a microfiber filter paper which has been oven dried for one hour. Then, the filter paper is stick on the filter holder that placed on the filter flask. Sample is poured about of 50-100ml onto the filter paper, and applies suction to the sample through vacuum pump attached to the filter flask. The sample will immediately flow through the filter paper and holder, and drip into the filter flask (*Figure 6*). Then, filter paper is removed from the apparatus and oven dry for one hour. The difference weight of filer paper before and after the suction indicated the TSS of the samples.

Figure 6. TSS flask and pump

3.2 Construction activities

Other than rainfall event, the water quality parameters in the project are compared to the construction progress activities or phases in the study. Therefore, the water quality at a specific time can be traced by the activities progress on the construction site, such as earthwork, piling, concreting, and others. Progress of construction activities in this study is obtained through progress chart provided by the contractors and Department of Development Management, UKM. It is noted that the construction activity schedules are available for all new constructions except new library building. Other than that, this paper focus only on the major construction activities such as earthwork, piling , building works, external works, mechanical and electrical, and infrastructure.

In this study, samples are collected and tested in three phases. The time frame for the phases are May 15, 2009 to May 25, 2009(3 samples), Nov 30, 2009 to Feb 1, 2010 (10 samples), and Feb 28,2011 to April 24, 2011 (7 samples) for Phase 1, Phase 2, and Phase 3 respectively.

3.3 Rainfall

In this research, rainfall data is obtained by installing rain loggerwhich is from RainwiseIncthe site near the UKM Lake (*Figure 7*). The rainfall data was logged every 10 minutes, and collected every week. In this paper, daily rainfall data is used for analysis in order to relateto theparametersthat are obtained once a week. Data for rainfall is available over the three phases of study including before and after the experimental period. In this study, the rainfall data was observed to determine the relationship with the water quality parameters that obtained for the lake and the monsoon drain.

Figure 7. Rainlogger by Rainwise Inc.

4. RESULT AND DISCUSSION

4.1 Water Quality and Rainfall

Figure 8 shows the result of rainfall event mapped to the value of water quality parameters for all three phases.

4.1.1 pH and rainfall

The result shows that pH value for Phase 1 and 3 are within the permitted range which is 6.5 to 9.5 for both lake and monsoon drain, even though rainfall event occurs before or on the day of samples were tested. However, for Phase 2, five samples exceeded the limit, while others are in the permitted range. On week 4 (November 30, 2009), the pH value is 6.0, and there was no rainfall on the sampling day, but rainfall event occurred two days prior to sampling. Onweek 5 (Dec 7, 2009), the pH value was 6.3 at lake and 6.0 at monsoon drain. It is noted that there is no rainfall event on the day of sampling, but there were rainfall events occurred from Dec1 to Dec 4, 2009.

Other than that, on week 8 (Dec 28, 2009), the pH value was 6.2 for Monsoon drain and there was also no rainfall event on that day. Eventually, the rainfall event was observed on the Dec 26,2009, and Dec 27, 2009 with 87mm and 3.7mm rainfall respectively. Subsequently on week 9 (January 4, 2010) pH value is 6.1 for the drain and the rainfall was 26.7mm. It is also observed that the rainfall event occur every day before the sampling which was from December 29 to Jan 5, 2010.

Therefore, it can be concluded that the rainfall influence the pH value of the lake and monsoon drain for the rainfall event occur before and on the same day of sampling. From the result observed, most of the pH value isnot in the permitted range for the monsoon drain. It is believed that factor that might affect the parameters is the construction activity at the surrounding area.

4.1.2 TSS and rainfall

For the Phase 1, on week 1(May 11, 2009), the value was 73.7 and 82.5 mg/l for lake and drain respectively. It was observed that no rainfall event on the day of sampling, but rainfall event was before the sampling day, the May 9, 2009 for 30.5mm.Phase 2 shows the increasing value of TSS for 7 out of 10 tests. For first test which was on week 4 (November 30, 2009), TSS value was 248 mg/l for monsoon drain. There was no rainfall on the observed day, and also no rainfall data available for the previous day. But, rainfall event occurred from Dec1 to Dec 4, 2009, indicated that due to the Northeast monsoon season, there might be rainfall event days prior to the sampling day.

Other than that, on week 5 (Dec 7, 2009), the TSS value was increased for both lake and monsoon drain which were 54 and 80 mg/l respectively. Even though no rainfall event on the sampling day, it is observed that no rainfall has occurred on the previous day except from Dec1 to Dec4, 2009. Subsequently for week 7 (Dec 21, 2009), TSS increases only for the lake with the value of 92 mg/l. There was no rainfall on the sampling day, but rainfall eventcontinuously from Dec 14 to Dec20, 2009.The TSS value for lake and monsoon drain onweek 8 (Dec28, 2009) were 94 and 184 mg/l with no rainfall event on that day, but high intensity of rainfall event occurred on Dec 26, 2009 with 87 mm while and on Dec 27, 2009 the rainfall is 3.7 mm.

TSS value for lake and monsoon drain also increase for week 9 (January 4, 2010) with the value of 142 and 556 mg/l respectively. Next, on week 12 (January 25, 2010), the TSS value is 118 mg/l for the lake with no rainfall event on the day of sampling, and rainfall event is only on January 23, 2010. The lake also has increasing of 96 mg/l of TSS value on week 13 (February 1, 2010) with no rainfall event detected on the same day and also before the sampling day.

Last but not least, the Phase 3 shows increment of TSS value which indicates 278 mg/l on week 14 (February 28,2011) for the monsoon drain. There was rainfall event of 0.74mm on the same day of sampling, and rainfall also occurred continuously from February 24 to 28, 2010. The result on week 17 (March 21, 2010) shows the lake has TSS value of 60 mg/l with of 1.96mm on the same day. Rainfall also occurred on March 18 to 20, 2010.

Therefore, based on the result obtained in this study area, it shows that rainfall events influence the TSS value. The rainfall events that occurred before or on the day of sampling were believed to gives higher value of TSS.

4.1.3 Turbidity and rainfall

Turbidity results on Phase 1 shows that the parameter was within the excepted range, while others show contrary results. For phase 2, out of 10 samples, only 3 samples were in the permitted limit for monsoon drain, while all samples for lake exceeded the permitted range.

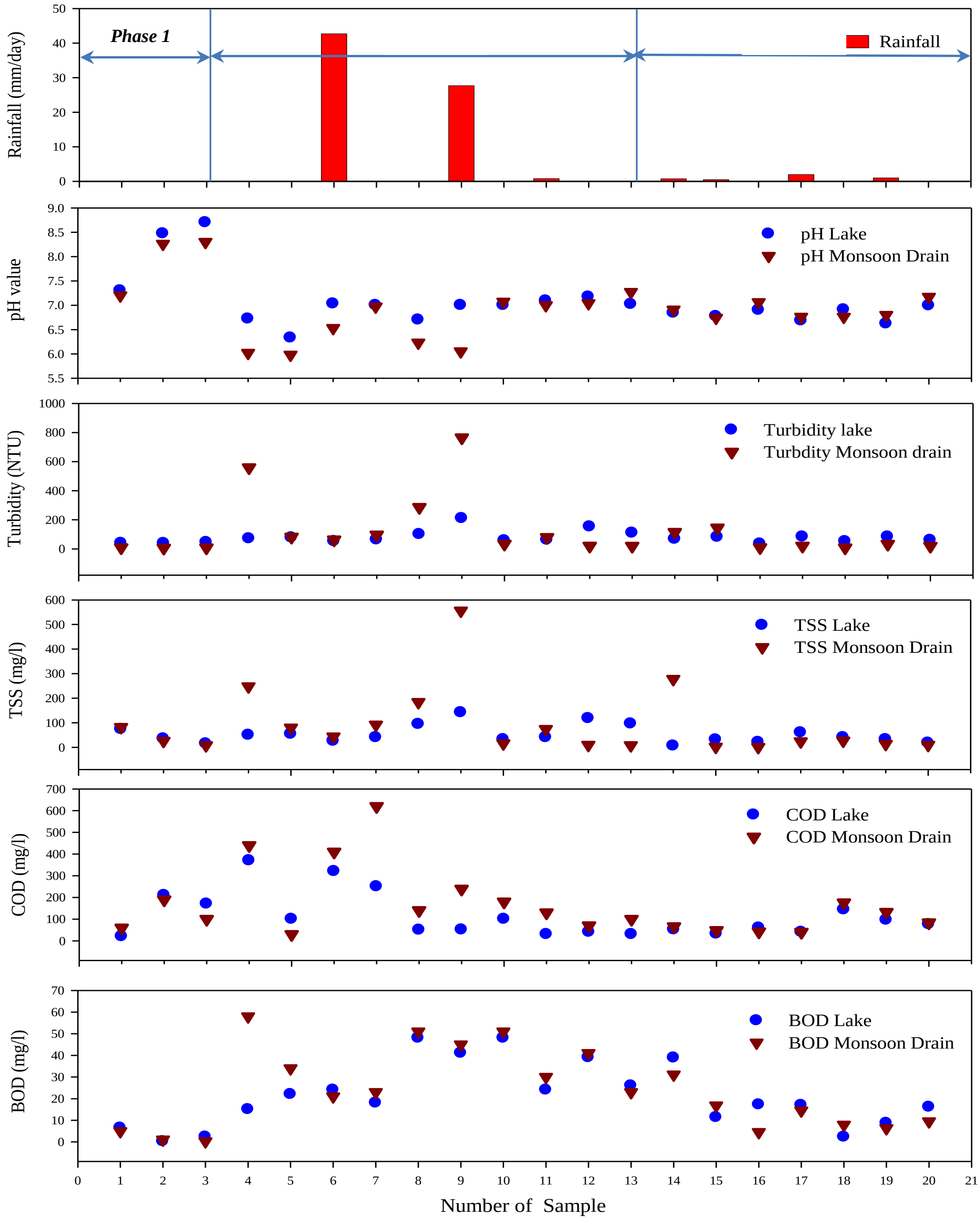

Figure 8. Result of rainfall, pH and TSS, Turbidity, BOD_5, and COD.

The highest values obtained were 765 NTU and 210 NTU for monsoon drain and lake respectively on week 9 (January 4, 2009) with rainfall of 27.7mm and also rainfall event occurred everyday for seven days prior to sampling day. There were also rainfall event on December 14, 2009, and January 18, 2010 that might leads to the higher value of turbidity. Other than that, other samples that were taking when there was no rainfall event, gives higher value of turbidity. For phase 3, from seven samples for both lake and monsoon drain, only one sample is within the permitted limit for lake , while only one samples is exceeded the permitted limit for monsoon drain. On week 14 (February 28, 2011), rainfall event occur every day in a week prior and including the sampling day. As a result, both lake and monsoon drain having turbidity value that more than the permitted limit. Other samples also indicated that higher value of turbidity was achieved on the raining day including prior and on the sampling day.

4.1.4 BOD_5 and rainfall

BOD_5 results show that only one value for both lake and monsoon drain is not in the permitted range, although there was no rainfall event on the day of sampling on week 1 (May 11, 2009). It is noted that there were rainfall events 2 days prior to the sampling day. Contrast with Phase 1, Phase 2 shows the contrary result when all 10 samples for both lake and monsoon drain exceeded permitted value. The results show that monsoon drain experienced higher value of BOD_5 compared to the lake with the highest value of 58 mg/l on week 4 (November 30, 2009). It is noted that even though there was no rainfall on the sampling day, rainfall event occur three days prior to the sampling day. It can be seen that the value of $BOD_5$are higher on the raining day, and also the sampling day with no rainfall, and rainfall that occur prior to sampling day.

Other than that, for Phase 3, the BOD_5 value for six out of seven samples for lake, and all samples for monsoon drain exceeded the permitted range. The highest value for this phase was 38.9 mg/l and 31.3 mg/l for lake and monsoon drain respectively, which were on week 14 (February 28, 2011). It wasrecorded that 0.74mm rainfall on the sampling day and there was also rainfall event that recorded everyday for seven days prior to the sampling day.

4.1.5 COD and rainfall

COD value for all Phases show that all samples except on week 1 (May 11,2009) for Phase 1 exceeded the permitted limit. TheCOD value was on week 2 (May 19, 2009) for both lake and monsoon drain with the value of 210 and 190 mg/l respectively. It is noted that there was no rainfall recorded on the sampling day, but the rainfall event occurred two days prior to the sampling day.

For Phase 2, the highest value of COD was obtainedon week 4 (November 30, 2009) for the lake with the reading of 370mg/l, and rainfall recorded three days prior to the sampling day, but there was no rainfall is recorded on the sampling day. On the other hand, COD value of 620 mg/l was captured on week 7 (December 21,2009) for the monsoon drain with no rainfall event recorded on the sampling day, but rainfall event are recorded every day for seven days prior to the sampling day.

For the Phase 3, all samples are exceeding the permitted limit with the highest value are 144 and 176 mg/l for lake and monsoon drain respectively on week 18 (March 29, 2011). There was no rainfall on the day of sampling, but rainfall event occurred on the fourth and fifth day prior to the sampling day.

It can be concluded that most of the COD value obtained for monsoon drain are higher than lake. The value of COD exceeding permitted value not only when there was no rainfall event on the sampling day, but also when there was rainfall event recorded on the sampling day. Therefore, the parameter value even higher when there was rainfall events recorded for several days prior to the sampling event.

4.2 Water quality and Construction

4.2.1 Phase 1

Table1. Result of pH, TSS,Turbidity, BOD_5, COD, and construction activity.

Construction Phase			Phase1			Phase 2										Phase 3						
		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
BUILDINGS	Research	Earthwork		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Piling				■	■	■	■	■	■	■	■	■	■							
		Building works				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		external works				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	DCS	Building works														■	■	■	■	■	■	■
		External works															■	■	■	■	■	■
		TES Tank														■	■	■	■	■	■	■
		TES Plant														■	■	■	■	■	■	■
	Eng Com	Earthwork				■	■	■	■	■	■	■										
		Piling				■	■	■														
		Building work				■	■	■	■	■	■	■	■	■	■							
		M&E													■	■	■					
		External				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
		Infraworks														■	■	■	■	■	■	■
WATER QUALITY TESTS	pH	Lake	7.3	8.5	8.7	6.7	**6.3**	7.0	7.0	6.7	7.0	7.0	7.1	7.2	7.0	6.8	6.8	6.9	6.7	6.9	6.6	7.0
		Drain	7.2	8.3	8.3	**6.0**	**6.0**	6.5	7.0	**6.2**	**6.1**	7.1	7.0	7.0	7.3	6.9	6.7	7.1	6.8	6.8	6.8	7.2
	TSS	Lake	**73.6**	35.0	15.0	50.0	**54.0**	26.0	40.0	**94.0**	**142.0**	32.0	40.0	**118.0**	**96.0**	6.0	31.0	21.0	**60.0**	40.0	32.0	18.0
		Drain	**82.5**	26.0	8.0	**248.0**	**80.0**	44.0	**92.0**	**184.0**	**556.0**	16.0	**74.0**	10.0	8.0	**278.0**	2.0	1.0	24.0	27.0	14.0	10.0
	Turbidity	Lake	39.5	38.1	45.2	**70.5**	**76.7**	**51.7**	**63.2**	**99.7**	**210.0**	**56.8**	**61.7**	**152.0**	**109.0**	**67.0**	**81.3**	34.9	**83.1**	**51.5**	**82.8**	**60.0**
		Drain	9.4	6.5	8.1	**559.0**	**82.1**	**63.2**	**96.9**	**286.0**	**765.0**	34.3	**79.4**	20.5	19.3	**115.0**	145.0	9.9	20.0	8.2	33.0	19.2
	BOD	Lake	**6.5**	0.2	2.3	**15.0**	**22.0**	**24.0**	**18.0**	**48.0**	**41.0**	**48.0**	**24.0**	**39.0**	**26.0**	**38.9**	**11.3**	**17.2**	**17.0**	2.3	**8.7**	**16.1**
		Drain	**5.0**	1.1	0.3	**58.0**	**34.0**	**21.0**	**23.0**	**51.0**	**45.0**	**51.0**	**30.0**	**41.0**	**23.0**	**31.1**	**16.8**	**4.5**	**14.5**	**7.9**	**6.3**	**9.5**
	COD	Lake	20.0	**210.0**	**170.0**	**370.0**	**100.0**	**320.0**	**250.0**	**50.0**	**51.0**	**100.0**	**30.0**	**40.0**	**30.0**	**52.0**	**32.0**	**60.0**	**40.0**	**144.0**	**96.0**	**76.0**
		Drain	**60.0**	**190.0**	**100.0**	**440.0**	**30.0**	**410.0**	**620.0**	**140.0**	**239.0**	**180.0**	**130.0**	**70.0**	**100.0**	**66.0**	**48.0**	**42.0**	**40.0**	**176.0**	**132.0**	**84.0**

within permitted limit
beyond permitted limit

Table 1 shows the results of parameters value with experimental phases and construction activities involved in the study. The result shows that all pH value lies within the permitted range which relates that only earthwork activity was in progress for Research Centre in this phase. On the other hand the TSS value is high for the week1 for both lake and monsoon drain even though there is no construction activity at that time. This result indicates that there might be error while handling the experiment.

It was found that turbidity values were in the permitted limit for this phase. On the other hand, BOD_5 values obtained for week 1 for both lake and drain were beyond the permitted limit, but others were satisfactory. Similar to the BOD_5, COD value attained beyond the permitted limit for monsoon drain but satisfactory for lake while other weeks were in the permitted limit for both.

4.2.2 Phase 2

In this phase, the construction was started on the Research Centre for the activities such as piling, building works, and external works. Engineering complex construction activities were also started in this phase for earthwork, piling, building, and external works. On the other hand, the construction of DCS was not started in this phase yet.

The parameters value for this phase was started increased based on the activities of construction for the new buildings. For pH, the result of week 5 for lake was beyond the permitted range (6.3), while other weeks were satisfactory. Contrary with lake, there were four weeks that pH value for monsoon drain obtained exceeded the permitted range which are week 4,5,8, and 9.

Results show that TSS value obtained for lake is exceeded limit for six weeks with the highest value of 142 mg/l on week 9. Similar to lake, TSS value for monsoon drain also experienced exceeded permitted limit for six weeks with the highest value of 556 mg/l on week 9.

All samples for all ten weeks show that the turbidity value were beyond the permitted limit for lake. The highest reading for turbidity was recorded 210 mg/l on the week 9. Other than that, seven weeks samples were beyond the permitted limit for monsoon drain with the highest reading obtained was 765 mg/l for week 9.

BOD_5 experimental results shows that all samples tested in this phase were exceeded the permitted limit for both lake and monsoon drain. For lake, the highest reading was 48 mg/l for week 8 and 10, while monsoon drain was 58 mg/l for week 4.

Similar to BOD5, the results of COD obtained show that all samples tested were exceeded the permitted limit for both lake and monsoon drain. Highest reading recorded for the lake was 370 mg/l for week 4, while monsoon drain was 620 mg/l for week 7.

In this phase, it is perceived that the highest value of the parameters lies on the week 4 and 9. At this week 4, the construction activities were started for both Research Centre and Engineering complex. Therefore, it is believed that as construction activities began the water quality of the lake and monsoon drain started to contaminated.

4.2.3 Phase 3

The construction for DCS building started at Phase 3. The activities involved were building works, external works, and TES tank and plant. Activities of other new buildings were still on progress in this phase except piling for Research centre. Other than that, earthwork, piling, and building works for Engineering complex were completed.

Results show that all pH values for lake and drain in this phase were within the permitted range. It shows that the increasing of construction activities for the DCS were not influence pH for both lake and monsoon drain. On the other hand, the result shows that the value of TSS was beyond the permitted limit for week 17 with 60 mg/l and week 14 with 278 mg/l for lake and monsoon drain respectively. It is noted that the sample of monsoon drain for TSS test for week 14 is the first week of Phase 3. The tremendously increaseof 280 mg/l from the week 13 (Phase 2) shows that construction activities of DCS were influence this parameter.

The turbidity result of lake shows that the parameter value was beyond the permitted limit for week 19 with the reading of 82.8 mg/l. Other than that, turbidity value for the monsoon drain were also exceed the permitted limit for week 14 with the reading of 115 mg/l. Similar with TSS, the parameter for monsoon drain which was in the first week for Phase 3 were tremendouslyincreased. It also shows that the influence of the progress of DCS construction activities in the area.

Figure 9. Monsoon drain polluted by sedimentation from construction.

Figure 10. Monsoon drain (a) before construction and (b) during construction.

The results of BOD_5 shows that the six weeks out of seven weeks for the lake, and all seven weeks for monsoon drain were not in the permitted limit. The highest reading for both lake and monsoon drain were recorded on the week 14 with 38.9 mg/l for and 31.1 mg/l respectively.

The COD results achieved in this research shows that all samples were not in the permitted limit for both lake and monsoon drain. The highest value obtained were 144 mg/l and 176 mg/l for lake and monsoon drain respectively. It is noted that both results were obtained on the week 18.

In this phase, it is found that most of the highest values for the parameter obtained were on the week of 14, and decreased for the following weeks. The week of 14 is the first week in the Phase 3, where DCS construction activities were started. Even though some of the activities such as earthwork, piling, and building works for engineering complex were completed, the reading for most of the parameters was not lies in the permitted limit.Therefore, the starting of DCS construction activities shows the decreasing of water quality, while completions of some activities of engineering complex enhanced the water quality for both lake and monsoon drain.Based on the result achieved, construction is obviously affecting the value of parameters. Although the controlling system for the effluent from the construction sites is provided, there still have effluent channelled especially into the monsoon drain. Figure 9 shows that the monsoon drain is polluted due to the sedimentation, while Figure 10 is the differences of monsoon drain before the construction Figure 10(a) and during the construction (Figure 10(b)). Other than that, there is an abandoned building near the engineering complex that to contributed to the parameters obtained. The Moot Court of Faculty of Law is uncompleted due to some reasons, and it was found that material and waste from the site were not managed properly, and might contribute to the parameters obtained in the research.

5. CONCLUSION

Evaluating water quality as an effect of constructions surrounding study area was donein three phases.In Phase 1, only the earthwork of Research Centrewasin progress started in the second test of the parameters. Therefore this showsthat no effect on the parameters value for Phase 1. For the Phase 2, the values of parameters are increased extensively compared to Phase 1 especially for the monsoon drain. Phase 2 involves piling, building works and external works for both Research Center and Engineering Complex. This gives the reason on the higher value of parameters which effluent is believedto convey from construction sites to monsoon drain and lake.

For the Phase 3, the construction activities are still in progress for Research Centre and M&E, external work and infrastructure works for Engineering Complex. Other than that, DCS construction is alsostartedin but only the result of pH lies in the permitted range. In this phase, the week 14 which is also the first week in Phase 3 shows the tremendous increased of parameters.

Beside construction, rainfall is found to be contributed to the higher value of parameters that triggered by the construction. In this study, most of the parameters result obtained which are not in the permitted range were also found no rainfall event recorded on that day. It is believed that the results were influenced by the rainfall event that occurred days before the result was obtained. It was also found that higher result of parametersvalues are achieved when there is rainfall event recorded on the same day of sampling.

Construction for new buildings is needed yet the impact also must be well planned and manage accordingly. Channelizing effluent from construction is a priority especially when the construction is within the wetland that involved aquatic life or in the catchment involves water resources. From the study, the author recommends that any proposed construction should be mapped to the wetland and catchment area involve in order predicting the impact of the construction to the water quality while the construction is in progress. It is also recommended that water quality is evaluated from pre-construction throughout post construction period to trace any abnormalities contaminant in the water.

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