Determining Spatial and Temporal Changes of Water Quality in Hlaing River using Principal Component Analysis

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Abstract

Water quality of a River is important as it is used for drinking, domestic purpose and agriculture. Hlaing River is one of the most important rivers in Yangon Region. The River plays an important role to supply water transportation for Hlaingtharyar, Insein and Htantapin Townships. The objective of the paper is to assess the change of water quality in Hlaing River in the wet and dry seasons. The secondary data used in the study are monthly mean temperature in Yangon (Average) between 2007 and 2016 and monthly rainfalls in Yangon (Average) between 2007 and 2016. Primary data are collected for sampling points. 8 numbers of samples were collected at different selective sampling points. A number of physiochemical water quality parameters including Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS) are tested. Principal component analysis in SPSS is used to know the correlations of the variables and to determine how many important components are present in the data. Sample points located at the same river and nearer places are in same component.

According to the water quality surveys, the water quality of Hlaing River met the level of Class (III) of the Interim National Water Quality Standards of Malaysia (for Water supply) in wet season because of dilution process at that time and in dry season some part of Hlaing River met the level of Class (IV) of the Interim National Water Quality Standard of Malaysia (for irrigation purpose).

Keywords: *Hlaing River, spatial and temporal changes, industrial zones, dilution, irrigation*

I. INTRODUCTION

This paper is assessing water quality of Hlaing river which is mainly use of transportation purposes in Yangon Region. There are a lot of national and international standards of water quality assessment. In this paper the researchers classify and assess the result of water quality by using the Interim National Water Quality Standards of Malaysia (INWQS), a set of standards derived based on beneficial uses of water. As Myanmar and Malaysia are consisting of South East Asia countries, they have similar topography and environmental conditions.

Currently, Myanmar has already set up emission standards. However, it is still need to lay down the standards for ambient air quality and drinking water quality standards. In the absence of those national standards, the Ministry of Natural Resources and Environmental Conservation (MONREC) stated that internationally accepted environmental standards of World Health Organization (WHO) guidelines, to be adopted for any environmental assessment.

The water quality survey from “Project on capacity development in basic water environment management and Environmental Impact Assessment (EIA) system in Myanmar” is originally composed of total five-time surveys: in February 2016, June-July 2016, January 2017, June-July 2017 and February 2018 in order to cover the dry season and rainy season in two years, 2016 to 2017. In the water quality surveys, 21 parameters are collected and measured for water quality analysis. The assessment of project paper is to analyze the resulted data from water quality surveys which was implemented during 5 periods in 3 years.

This paper aims to analyze the current status of the Hlaing River through the on-site measurement and laboratory analysis.

II. DATA AND METHODOLOGY

A. Guideline levels and Classification

Ministry of Health and Sports (MOHS) and MONREC enacted Drinking water quality standard and National Environmental Emission Guideline for water. In Myanmar, there is no surface water quality standard. So, the researcher uses INWQS for surface water in order to compare with the results.

B. Sampling Parameters

For the water quality surveys the parameters are BOD, COD and TSS. In this project paper, these will be assessed and mentioned by using ArcGIS.

Table 1 shows the Interim National Water Quality Standards of Malaysia for surface water and the class mentioned in table are definitions of specific use of water quality with limit values.

Table I: Limit value and class of surface water quality parameters according to the Interim National Water Quality Standards of Malaysia (INWQS)

PARAM-ETER	UNIT	LIMIT VALUE and CLASS			
		IIB	III	IV	V
Biochemical Oxygen Demand (BOD)	mg/l	3	6	12	> 12
Chemical Oxygen Demand (COD)	mg/l	25	50	100	> 100
Total Suspended Solid (TSS)	mg/l	50	150	300	> 300

Source: INWQS

Note: Class IIB is recreational use with body contact,
Class III is Water supply – Extensive treatment required
and Common of economic value, and tolerant species; livestock drinking,
Class IV is irrigation purpose, and
Class V is none of the above.

C. Sampling method

Water samples were collected three times and then mixed in bucket. Then, take off 100 ml with sample bottle and send to the laboratory. Surface water was taken directly by a sampling bottle or using a plastic sampling bucket. In addition, Van Dorn Water Sampler was used to collect a water sample from a specific depth as needed.

D. Laboratory analysis method

BOD is analyzed by using Respirometric method (HACH Method 10099) in DOWA Eco-system-Myanmar Co., Ltd.

The researchers analyzed COD Cr with the Japanese Standard JIS K0102 (2016) 20.1 which is developed by OSUMI CO., Ltd.

TSS is analyzed by OSUMI CO., Ltd. in order to the method of Environment Agency Notification No. 59, 1971.

III. RESULT AND DISCUSSION

A. Location of the Study Area

Hlaing River is the middle section of a tributary of Ayeyarwaddy River, and its name evolves as Myit Ma Kha River, Hlaing River, and Yangon River as it flows down toward the sea. The length of Hlaing River is around 110 km-long and the starting point is the boundary between Yangon Region and Bago Region, and the ending point is before confluence of Pan Hlaing River between Hlaing Township and Hlaing Thar Yar Township in Yangon City (Figure 1).

The project mainly focuses on the downstream area of Hlaing River located in Yangon City because there are many industrial zones and the water quality may be deteriorated by the impact of wastewater from industrial zones.

This paper were be evaluated the water quality status of Hliang River which is based on the collected information and the data of "Project on capacity development in basic water environment management and EIA system in Myanmar" which is bilateral technical cooperation project between Myanmar and Japan during the project implement from June, 2015 to May 2018 in Yangon Region.

Figure 1. Location Map of the Study Area, Hlaing River

B. Spatial and Temporal Variations of Water Quality in Hlaing River

Basin map of Hlaing River with locations of industrial zones in the river basin is shown in figure 2. Hlaing River Basin is long in North-South direction, and the industrial zones are located in the most downstream area. Hlaing River connects with Yangon River and drains to the Andaman Sea.

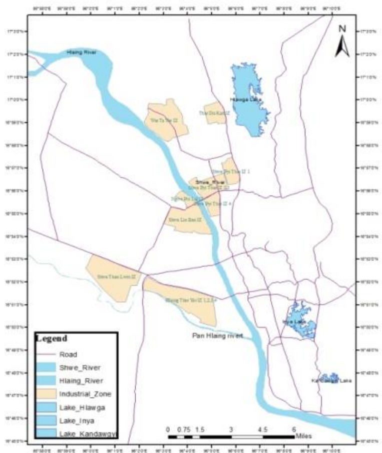


Figure 2. Hlaing River Basin and Locations of Industrial Zones

1): Comparison and Analysis of BOD in Dry and Wet Season

At the points of Hlaing - 1 and Pan Hlaing - 2, the value of BOD for all sampling points meets the level of Class V of the Interim National Water Quality Standard of Malaysia because the untreated waste water discharge along the Hlaing River was high at dry season. In the case of wet season, the values of BOD along the Hlaing River and Pan Hlaing River meet the level of Class IIB of INWQS for recreational use with body contact. It can be assumed that the dilution of heavy rain may have an effect on the value of BOD in river water quality and the suspension of distillery factories were happened at that time (Figure 3).

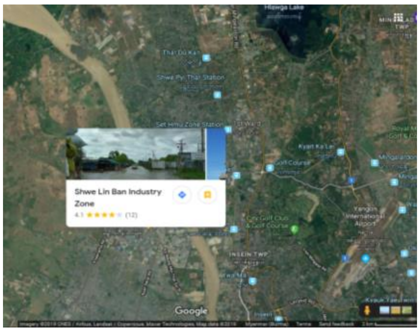
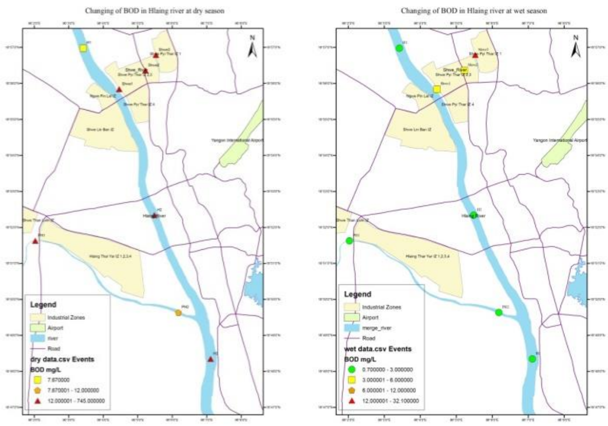


Figure 3. Location of Industrial Zones in the Study Area

According to the results of wet season, in Shwe creek the value of BOD at the points of Shwe - 1 and Shwe - 2 meet the level of Class III of INWQS with the purpose of water supply and fishery in the requirement of extensive treatment while the point of Shwe - 3 meets the level of Class V of INWQS which is located at Shwe Pyi Thar IZ area, may be polluted by the industrial waste water.

The following figure (4) shows comparison of changing BOD along Hlaing River Basin in dry and wet season.



(a) (b)

Figure 4. Comparison of Changing BOD along Hlaing River Basin in Dry (a) and Wet Seasons (b)

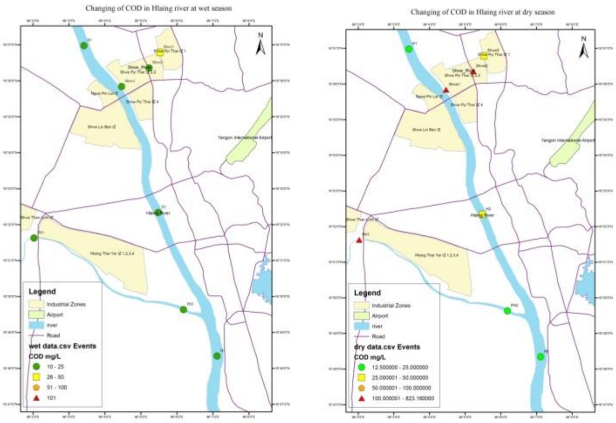
2): Comparison and Analysis of COD in Dry and Wet Season

In the case of wet season, the value of COD along the Hlaing River, Pan Hlaing River and some points at the sub stream of Hlaing River, especially Shwe - 1 and Shwe – 2, meet the level of Class IIB because the dilution of heavy rain and the suspension of distillery factories may effect on the value of COD in river water quality. The upper stream of creek path (Shwe-3) meets the level of Class III of INWQS with the purpose of water supply and fishery in the requirement of extensive treatment. But the water quality was relatively different from all sampling points which can be caused by some other pollution activities of Shwe Pyi Thar IZ so that further investigation is needed near it.

In the dry season, the water quality at the middle point of Hlaing River (Hlaing - 2), was better than that of upstream and downstream points, which was indicated by the impact of Shwe creek in which the value of COD at the points of Shwe - 1 and Shwe - 2 meet the level of Class III and Shwe - 3 meets the level of Class V of INWQS.

In Pan Hlaing River that is flowing through the Hlaing Thar Yar IZ into Hlaing River, the water quality of Pan Hlaing - 1 meets the level of Class V of the INWQS at the dry season. The downstream of Pan Hlaing River (Pan Hlaing - 2) was within the level of Class IIB.

Figure 5 shows comparison of changing COD along Hlaing River Basin in dry and wet season.



(a) (b)

Figure 5. Comparison of Changing COD along Hlaing River Basin in Dry (a) and Wet Seasons (b)

3): Comparison and Analysis of TSS in Dry and Wet Season

In the dry season, the value of TSS at the points of Hlaing-1 meets the level of Class IV of the Interim National Water Quality Standard of Malaysia with the purpose for irrigation while the other two points of Hlaing-2 and Hlaing-3 meet the level of Class V of INWQS. The former can be assumed that there may have some other activities to happen erosion at the upstream of Hlaing River and the latter can be caused by increasing rate of erosion which is higher than that of the upstream of Hlaing River. It can be assumed that these two points is located at the downstream and near of industrial zones.

In the wet season, the value of TSS along the Hlaing River meets the level of Class V of INWQS because the rate of erosion and tidal fluctuation were relatively higher than the dry season. That is why the water color of Hlaing River was turned to brownish with the less transparency in color.

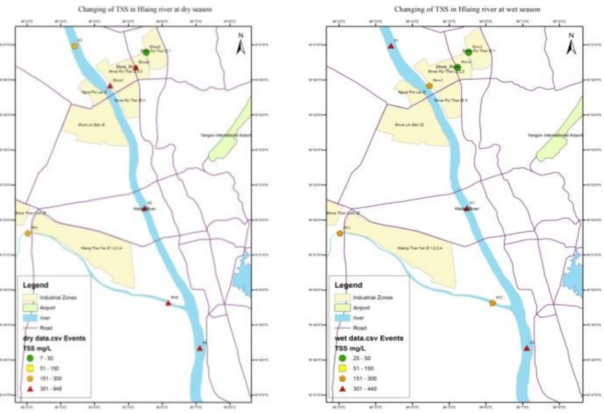
According to TSS results at the dry season, Pan Hlaing - 2 can be used for irrigation with the level of Class IV and Pan Hlaing -1 was within the level of Class V in INWQS. Pan Hlaing -1 and Pan Hlaing -2 meet the level of Class IV of INWQS at the wet season. It can be assumed that the downstream of Pan Hlaing is located at the downstream of industrial zones and their activities.

In the case of Shwe creek at the dry season, the value of TSS for Shwe - 1, meets the level of Class IIB while Shwe - 2 and Shwe - 3 meet the level of Class V according to INWQS. It can be assumed that there are no erosion activities near Shwe - 3 point. The water quality of the other points at Shwe Creek passed through Shwe Pyi Thar IZ area which may be caused by industrial activities.

In the wet season, TSS value at the Shwe - 2 and Shwe - 3 points meet the level of Class IIB of INWQS but the downstream point Shwe - 1 meet the level of Class IV of INWQS. It can be assumed that the downstream of Pan Hlaing is located at the downstream which is passed through the Shwe Pyi Thar industrial zone.

The differences between the dry and wet season are that the activities in Hliang River Basin and heavy rain can cause the erosion which is resulted in changing the value of TSS.

The following figure shows comparison of changing TSS along Hlaing River Basin in dry and wet season.



(a) (b)

Figure 6. Comparison of Changing TSS along Hlaing River Basin in Dry (a) and Wet Seasons (b)

C. Principal Component Analysis

To know 8 sample points in Hlaing River have similar patterns of responses i.e. do these points hang together to create construct? Principal component analysis (PCA) can explain the interrelationships among the variables of 8 sample points.

The main idea of PCA is to reduce the dimensionality of a data set consisting of many variables correlated with each other, either heavily or lightly, while retaining the variation present in the dataset, up to the maximum extent.

The 1st principal component retains maximum variation that was present in the original components. The principal components are the eigenvectors of a covariance matrix, and hence they are orthogonal.[5]

This paper studies water quality changes of 8 places. Each place is described by its attributes like BOD and COD contents according to the time etc. However, the complicated data will arise because many of them measure related places and variables. Therefore, PCA will do in this case is summarizing each station in the dataset with less characteristics.

The following table shows correlations in SPSS analyze by using bivariate. Form the table the most items have some correlation with each other ranging from r = -.146 for Shwe Creek 1 and Hlaing 2, "these are the nearest places" to r = 1 for the sample points in the same river. Due to relatively high correlations among items, this would be a good component. Fewer interrelationships variables can be broken up into multiple components such as sample points in Shwe Creek and Hlaing River.

Eigenvalue represents the total amount of variance. The total variance is made up to common variance and unique variance, and unique variance is composed of specific and error variance. Component 1 and 2 have the highest percentage of variance the former is 69.186% of variance in initial Eigenvalues and the latter is 30.669%and component 3 is 0.1% (Table 3).

To select the optimal number of components that are smaller than the total number of items, scree plot is performed which plots the eigenvalue by the component number. To choose components, one criterion is to have eigenvalues greater than 1. In Figure 7 the first two components have an eigenvalue greater than1. The first component has the highest total variance and the least components are at the last of the plot. Component 2 is making the joint position. The researcher selects two components on the basis of the scree plot.

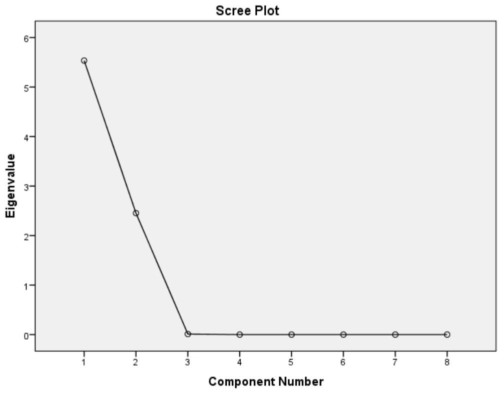


Figure 7. Scree Plot for Components

Component Matrix table contains component loadings, which are the correlations between the variable and the component. Hlaing 1, Hlaing 2, Hlaing 3, Pan Hlaing 1, Pan Hlaing 2 and Shwe 3 load heavily on the first component and the other two on the second component. This makes the output easier to read by removing the clutter of low correlations that are probably not meaningful anyway. Pan Hlaing 1 and Shwe 3 has fairly correlation with component 2. It can be clearly seen in figure 8.

Table IV. Component Matrix

Component Matrix[a]

	Component	
	1	2
Hlaing-1	.970	-.244
Hlaing-2	.963	-.269
Hlaing-3	.966	-.258
Pan Hlaing-1	.903	.426
Pan Hlaing-2	.962	-.271
Shwe-1	.128	.990
Shwe-2	.236	.971
Shwe-3	.959	.278

Extraction Method: Principal Component Analysis.

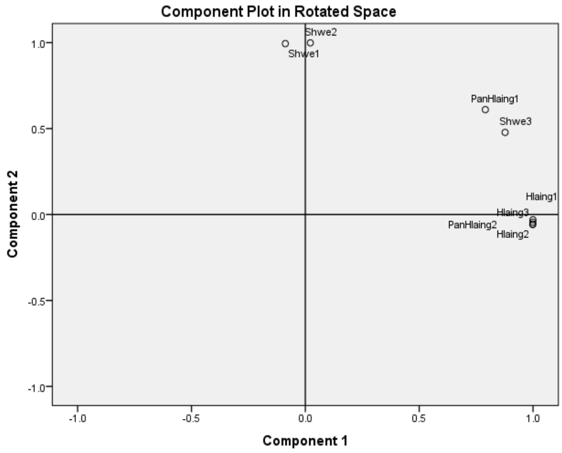


Figure 8. Component Plot in Rotated Space

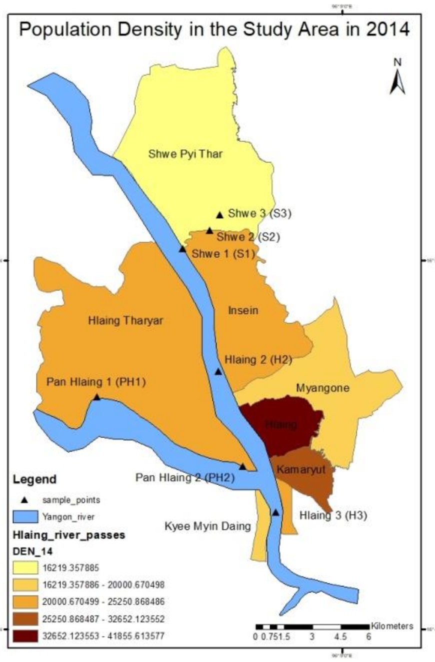


Figure 9. Population density and Sample Points

The study area is located in the western part of Yangon River. Rapid urbanization is pronounced in these large townships – Shwepyithar, Hlaingtharyar, Insein and Mayangon. Shwelinban industrial zone and Shwepyithar industrial zones are established in these townships. The consequences of human activities such as municipal wastewater, waste from the factories and urban drainage into the rivers effect on the water quality of the area. Chemical and biochemical contents in the water in dry season are more pronounced than wet season. Huge discharge of municipal wastewater into the river is one of the important factors.

IV. CONCLUSION

Hlaing River in Yangon Region has been selected as the study area because the impact of industrial zones is important for the quality of water. To examine the comparison of spatial and seasonal changes of surface water quality in Hlaing River physiochemical water quality parameters such as BOD, COD and TSS are tested.

The paper is applied on-site measurement and laboratory analysis result data of BOD, COD and TSS from 3rd and 4th water quality surveys which are mainly developed by the Project for Capacity Development in Basic Water Environment Management and EIA System.

The results of wet and dry season surveys were evaluated with respect to each sampling points of rivers and creek.

At the middle point of Shwe creek (Shwe-3), the water quality was significantly deteriorated, which was indicated by high level of COD and BOD. The result did not show marked deterioration of surface water quality in the flow direction of Hlaing River and Pan Hlaing River. The creek passing through the industrial zones and then flowing into Hlaing River, its water quality is significantly deteriorated by wastewater, which is indicated by low Dissolved Oxygen (DO) as well as high concentrations of COD and BOD.

In dry season, places located near the industrial zones have the high COD and the opposite true in wet season. Similarly, in dry season the content of BOD is high in nearly all places, but the value is less than 0.7 mg/l in wet season exception Shwe 3 point. In the study area, the content of BOD and COD in the water is high in dry season and low in wet.

Conduct a principal component analysis can determine how many important components are present in the data. It can highlight the correlation between the variables and components. Shwe 1 and Shwe 2 points (located near the Creek from Shwe Pyi Thar Industrial Zone to enter Hlaing River) have the same environmental background and Shwe 3 and Pan Hlaing 2 have the same situations such as located in the industrial zones. Hlaing 1, Hlaing 2, Hlaing 3 and Pan Hlaing 2 located along the rivers are one group. Therefore, PCA can point out the grouping of the variables on the plot.

In the Hlaing River of Yangon, the problem of various water discharged manner from industrial zones is one of the most important problems to protect water quality and its environment especially in Hlaingtharyar, Hlaing and Insein townships having the large number of population.

REFERENCES

[1] Desalination and Water Treatment (April, 2018), GIS – based analysis of water quality deterioration in the Nerus River, Kuala Terengganu, Malaysia

[2] How to perform a principal components analysis (PCA), retrieved from https://statistics.laerd.com › spss-tutorials › principal-components-analysis- ... 12 Nov 2019

[3] Myanmar Statistical Yearbook, 2017 Central Statistical Organization, Ministry of National Planning Economic Development

[4] Progress Report No. (4) Of Project for capacity development in basic water environment management and EIA system in Myanmar by JICA Expert Team (2018)

[5] Principal components Analysis, retrieved from www.statstutor.ac.uk › resources › uploaded › principle-components-analy... 10 Nov 2019

[6] Karn, S.K.; Harada, H. Surface Water Pollution in Three Urban Territories of Nepal, India, and Bangladesh. Environmental Management. 2001, 28, 483–496

Appendix

Table II. Correlation Matrix of Sampling Points in the Study Area

Correlation Matrix[a]

		Hlaing-1	Hlaing-2	Hlaing-3	Pan Hlaing-1	Pan Hlaing-2	Shwe-1	Shwe-2	Shwe-3
Correlation	Hlaing-1	1.000	1.000	1.000	.772	1.000	-.118	-.008	.862
	Hlaing-2	1.000	1.000	1.000	.755	1.000	-.144	-.034	.849
	Hlaing-3	1.000	1.000	1.000	.762	1.000	-.131	-.023	.856
	Pan Hlaing-1	.772	.755	.762	1.000	.753	.534	.629	.982
	Pan Hlaing-2	1.000	1.000	1.000	.753	1.000	-.146	-.037	.848
	Shwe-1	-.118	-.144	-.131	.534	-.146	1.000	.988	.401
	Shwe-2	-.008	-.034	-.023	.629	-.037	.988	1.000	.494
	Shwe-3	.862	.849	.856	.982	.848	.401	.494	1.000

a. This matrix is not positive definite.

Table III. Total Variance Explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.535	69.186	69.186	5.535	69.186	69.186	5.393	67.408	67.408
2	2.453	30.669	99.854	2.453	30.669	99.854	2.596	32.446	99.854
3	.012	.146	100.000						
4	8.310E-16	1.039E-14	100.000						
5	1.940E-16	2.425E-15	100.000						
6	7.542E-17	9.428E-16	100.000						
7	-2.145E-16	-2.681E-15	100.000						
8	-6.207E-16	-7.759E-15	100.000						

Extraction Method: Principal Component Analysis.

Results of Laboratory Analysis

Table V: 3rd Water Quality Result

No	No	Unit	2	3	4	5	6	7	8	9
	Location name		H1	H2	H3	PH1	PH2	Shwe1	Shwe2	Shwe3
			Hlaing-1	Hlaing-2	Hlaing-3	Pan Hlaing-1	Pan Hlaing-2	Shwe-1	Shwe-2	Shwe-3
	Sampling Date		30/1/2017	30/1/2017	30/1/2017	30/1/2017	30/1/2017	30/1/2017	30/1/2017	30/1/2017
	Sampling Time		09:30	10:25	09:12	11:13	10:00	12:30	13:08	13:45
1.	BOD	mg/L	7.67	14.33	15.38	120.00	10.38	745.00	618.75	34.38
2.	Total Suspended Solids (TSS)	mg/L	192.00	948.00	434.00	241.00	554.00	396.00	426.00	75.00
3.	COD Cr	mg/L	12.50	33.34	18.76	159.77	16.67	823.18	781.50	37.51

Results of Laboratory Analysis

Table VI: 4th Water Quality Result

No	No	Unit	2	3	4	5	6	7	8	9
	Location name		H1	H2	H3	PH1	PH2	Shwe1	Shwe2	Shwe3
			Hlaing-1	Hlaing-2	Hlaing-3	Pan Hlaing-1	Pan Hlaing-2	Shwe-1	Shwe-2	Shwe-3
	Sampling Date		18/9/2017	18/9/2017	18/9/2017	18/9/2017	18/9/2017	19/9/2017	19/9/2017	19/9/2017
	Sampling Time		10:10	11:05	12:01	15:41	14:45	13:11	13:46	08:40
1.	BOD	mg/L	1.16	1.80	1.26	1.57	0.72	5.41	5.94	32.07
2.	Total Suspended Solids (TSS)	mg/L	390	440	330	230	290	180	27	25
3.	COD Cr	mg/L	14	14	10	14	12	19	22	44