WATER QUALITY ASSESSMENT IN DERAMAKOT FOREST RESERVE 2017

by

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INTRODUCTION

A water quality assessment was carried out by the Hydrology Unit of Forest Research Centre (FRC) to assess the quality of water 5 rivers in Deramakot FR, namely Rawog River, Tangkulap Kecil River, Balat River, Deramakot River and Mannan River.

LOCATION OF STUDY AREA

A total of 5 sampling points represent the project watershed and its sub-catchment areas which predominantly drain through the project site. These sampling points are labelled W1 to W5 (Table 1, Figure 1). All the headwaters of these rivers derived from within Deramakot itself, except for part of Rawog River derived from adjacent oil palm estate in the north. The chemical analyses and water quality classes for all parameters tested for the sampling points in the project area are listed in Table 2. The weather conditions that occurred 24 hour before water sampling is taken is provided in Table 1, while the water quality classes for all selected parameters and chemical analysis tested for the water samples in this project area are listed in Table 2.

Table 1. The Location of Water Quality Sampling Point in Deramakot FR

Sample Point No.	Location	Surrounding Condition	Prevailing Weather conditions (24 hours)	Date of Sampling	GPS Location	
					Latitude	Longitude
W_1	Rawog River	Secondary forest	Clear weather	5th July 2017	$05^0$26.223’	$117^0$25.559’
W_2	Mannan River (Basecamp)			5th July 2017	$05^0$21.955’	$117^0$26.239’
W_3	Tangkulap Kecil River			20th June 2017	$05^0$19.445’	$117^0$22.113’
W_4	Balat River			20th June 2017	$05^0$19.556’	$117^0$35.351’
W_5	Deramakot River			20th June 2017	$05^0$17’05.16”	$117^0$32’35.47”

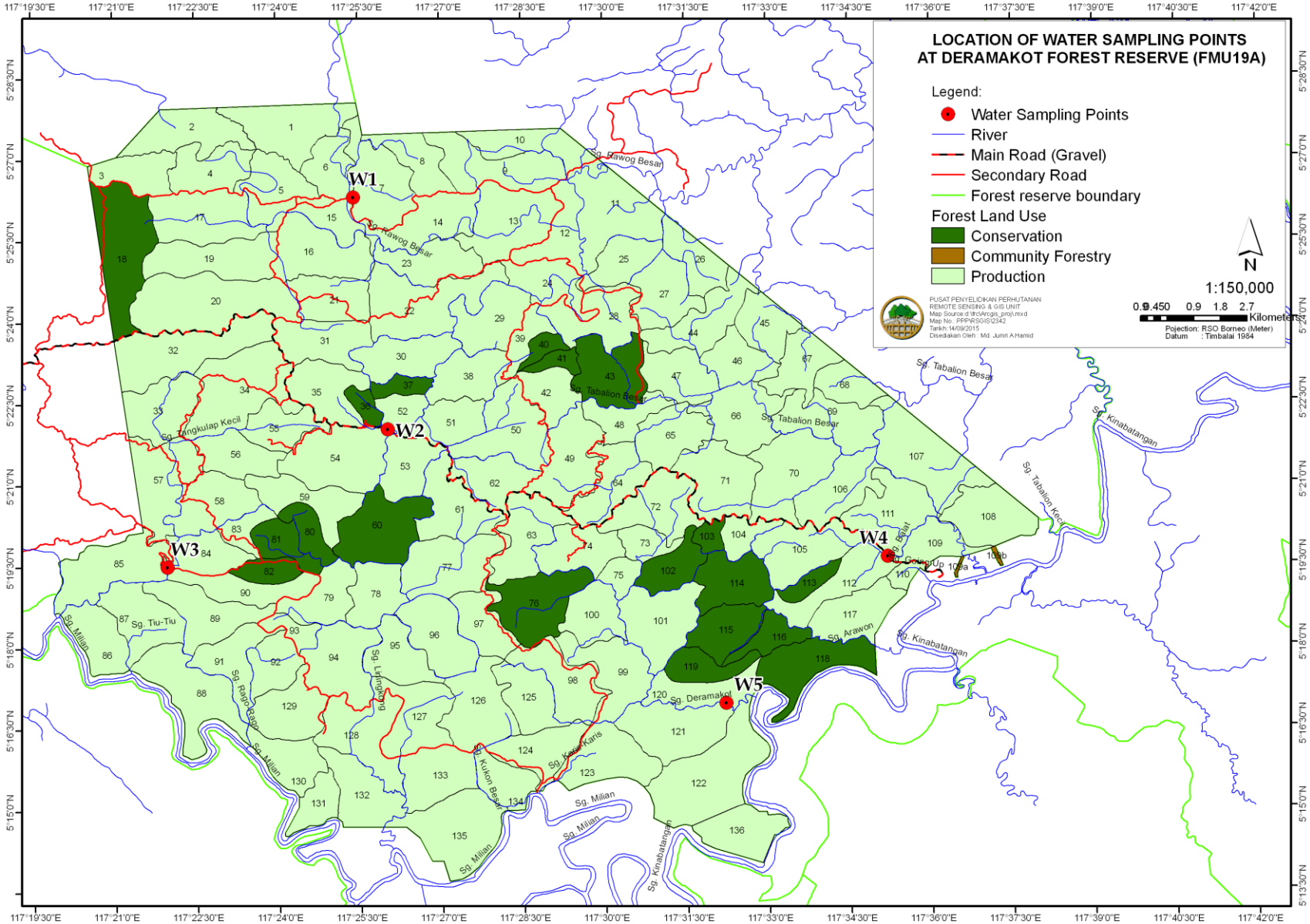


Figure 1 The location of 5 water sampling points W1 – W5 to assess river water quality in Deramakot Forest Reserve, Sabah.

RESULT

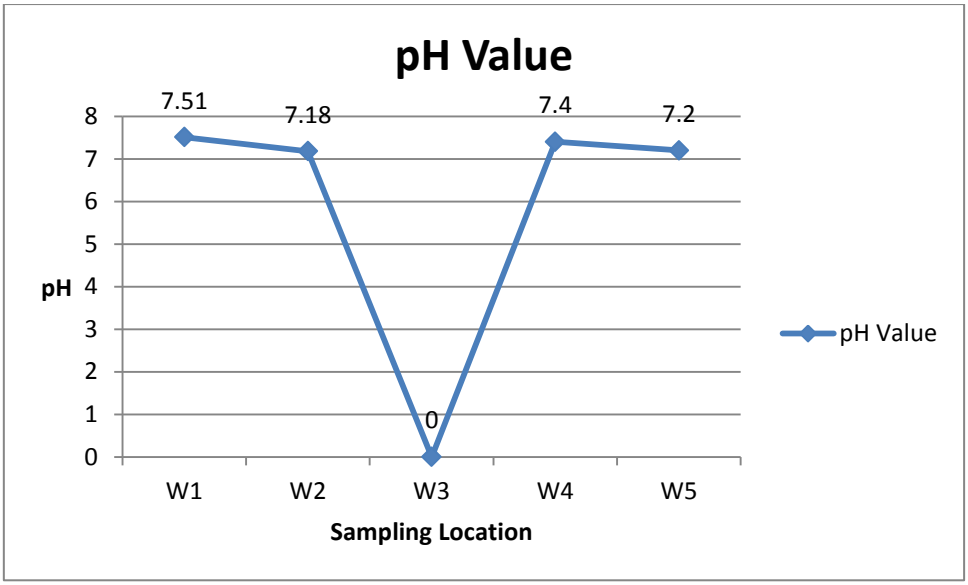
Water Quality

The chemical analysis and water quality classes for all parameters tested for the sampling points in the project area are listed in the table below.

Table 2. The results of chemical analyses and water quality classes for all parameter tested for sampling location W1, W2, W3, W4 and W5 in DFR Project Area. Note: Biological Oxygen Demand (BOD in mg/l), Chemical Oxygen Demand (COD in mg/l), Ammoniacal Nitrogen (AN in mg/l), Suspended Solid (SS in mg/l), Dissolved Oxygen (DO in mg/l), fecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l).

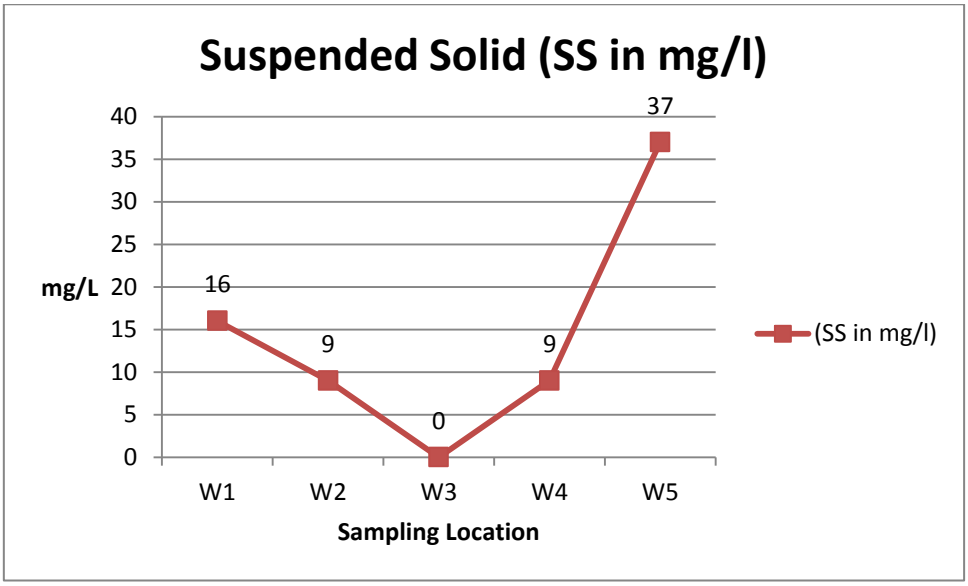
Sampling Location	Biological Oxygen Demand (BOD5 in mg/l)	Suspended Solid (SS in mg/l)	Chemical Oxygen Demand (COD in mg/l)	Ammoniacal-Nitrogen (as N3-N in mg/l)	Dissolved Oxygen, DO (mg/l)	pH Value	Oil & Grease (mg/l)	Total Coliform Count (MPN/100mL)	Fecal Coliform Count (MPN/100mL)
W_1	1	16	17.7	0.09	7.69	7.51	1.5	2200	2200
W_2	1	9	25.6	0.05	7.51	7.18	1.5	3500	790
W_3	NA*	NA*	NA*	NA*	NA*	NA*	NA*	NA*	NA*
W_4	1	9	64	0.1	8.1	7.4	1.5	16000	490
W_5	1	37	76.8	0.08	6.36	7.2	1.5	9200	1100
Minimum	1	9	17.7	0.05	6.36	7.18	1.5	2200	490
Maximum	1	37	76.8	0.1	8.1	7.51	1.5	16000	2200
Mean	1	17.75	46.025	0.08	7.415	7.3225	1.5	7725	1145
NWQSM*	**Class I**	**Class I**	**W1: Class I W2 : Class IIA W4 W5: Class III**	**Class I**	**W1, W2, W3 & W5 : Class I**	**Class I**	NA*	**W1 & W2 : Class I W4, W5 : Class IIA**	**Class IIB**

*NWQSM = National Water Quality Standard for Malaysia *NA = Not Available



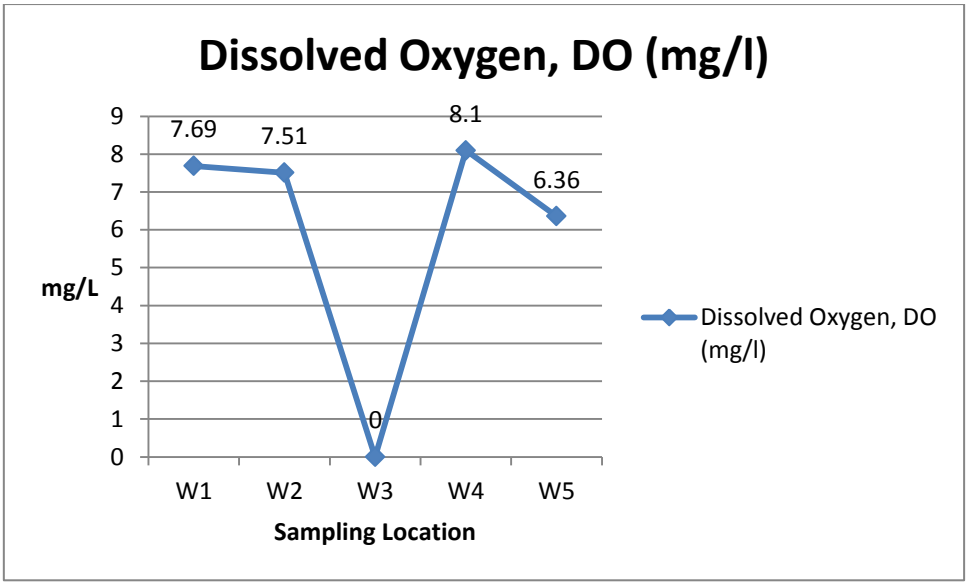
i) pH

pH is a measure of the hydrogen ion concentration in water. The concentration range of hydronium ions suitable for the existence of most biological life is narrow, typically between pH 6 to 9. The pH level for all sampling points were ranged between 6.5 and 8.5, therefore it is classified under Class I in NWQSM.



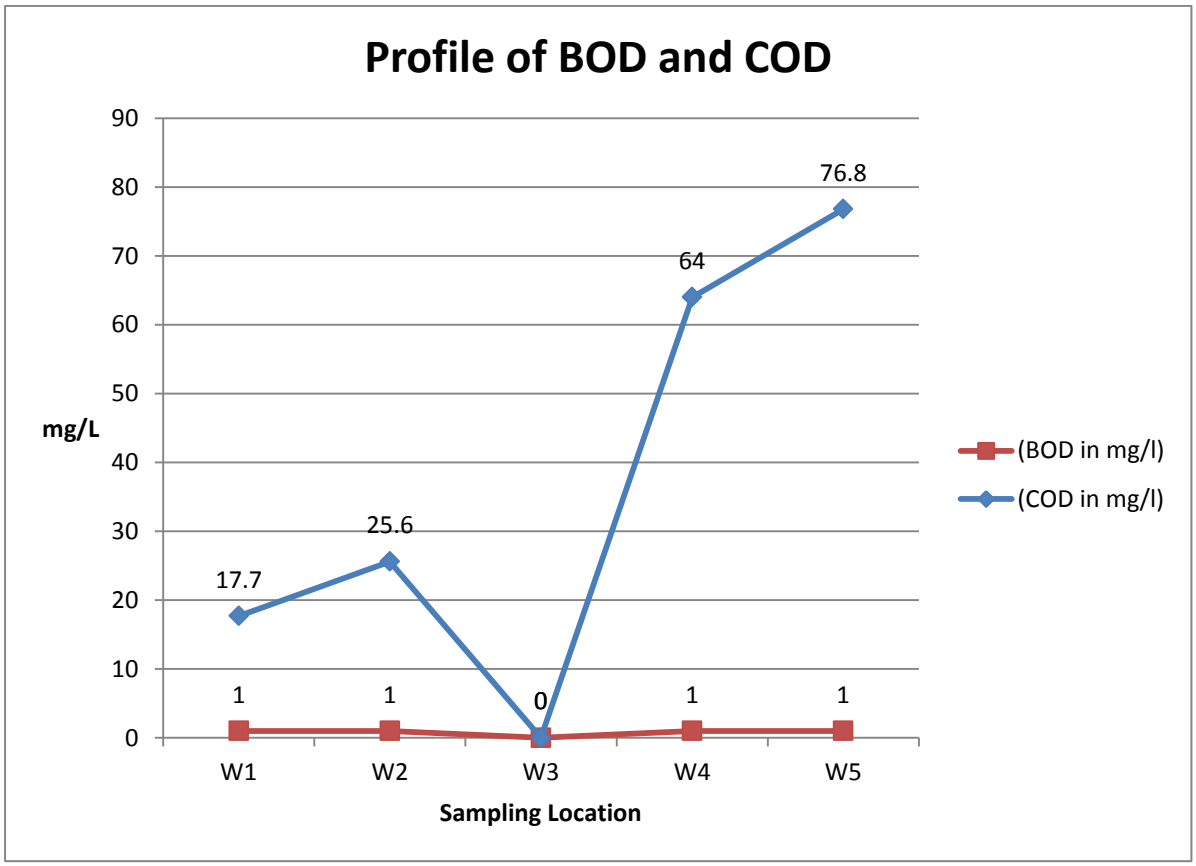
ii) Suspended Solid

Suspended Solid (SS) gives a measure of the turbidity of the water. SS cause the water to be milky or muddy looking, and it is an indicator of the amount of land disturbance within the catchment area and relates to the erosion that took place nearby sampling area or upstream. From the result, all sampling points SS levels categorised in Class I under the NWQSM.



iii) Dissolved Oxygen (DO)

DO is an important parameter in assessing water quality because of its influence on the organisms living within a water body. It measures the amount of oxygen (O_2) that dissolved in the water. A DO that is too low can harm aquatic life and affect water quality. From the results obtained, all sampling points of DO level are in Class I as stated under the NWQSM, except for W_5 which classified under Class IIA with DO level of 6.36 mg/l.

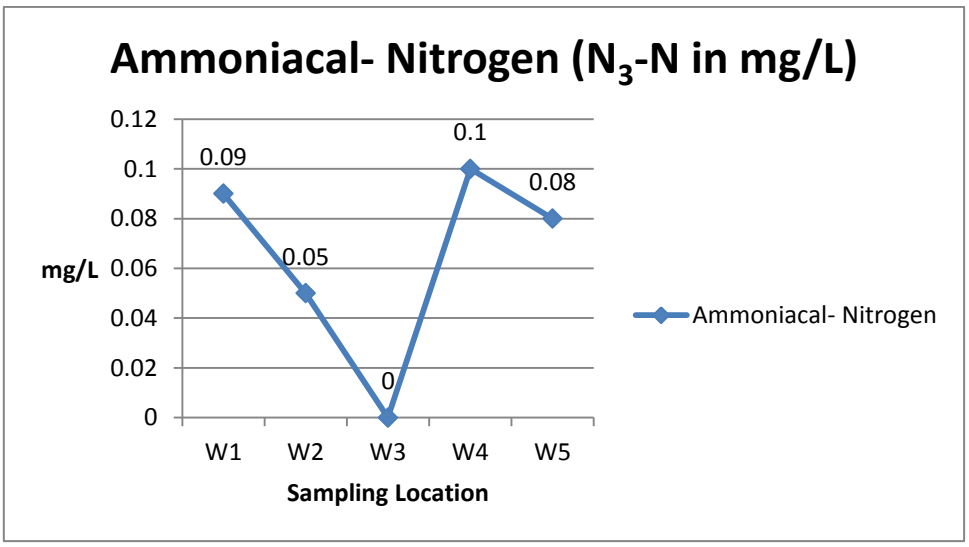


iv) Biological Oxygen Demand (BOD)

BOD refers to the amount of O_2 that would be consumed by the microorganisms (e.g., aerobic bacteria) while decomposing organic matter under aerobic conditions (Revelle and ReVelle, 1988). From the data, all sampling points are in Class I under the NWQSM.

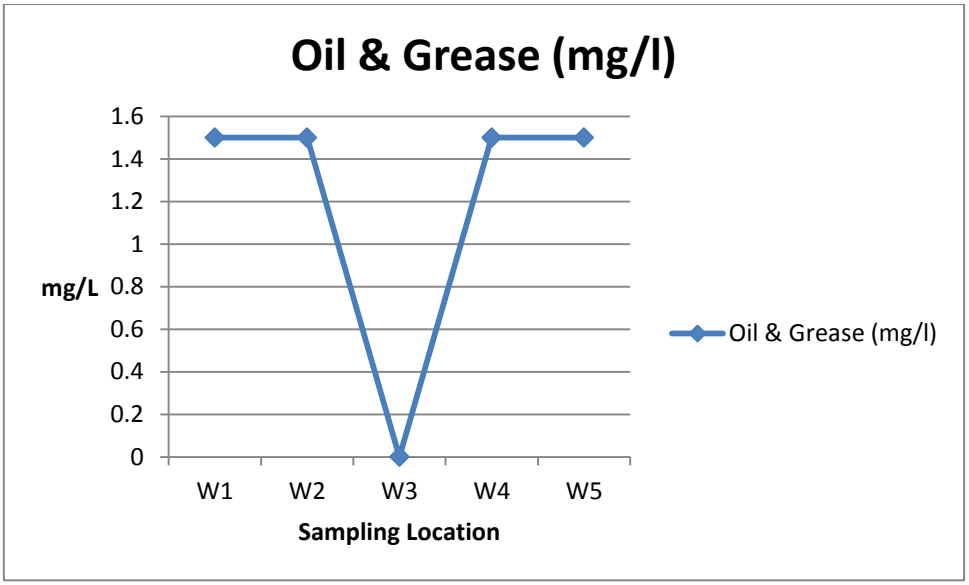
v) Chemical Oxygen Demand (COD)

COD is a measurement of the O_2 required to oxidize soluble and particulate organic matter in water. This parameter is an indicator of organics in the water and usually used in association with BOD. The COD level for sampling points of W_1 is in Class I under the NWQSM, while W_2 in class IIA. For sampling point W_4 and W_5 are in Class III.



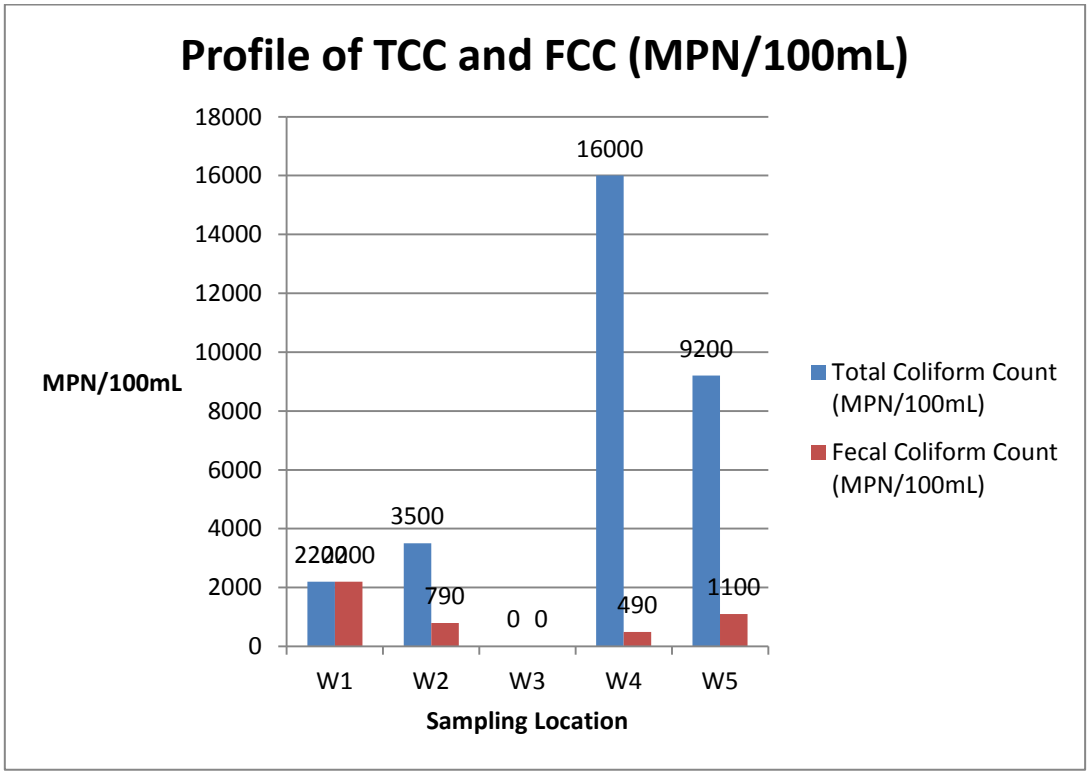
vi) Ammoniacal-Nitrogen (N_3N)

This parameter is an indicator of pollution from excessive usage of ammonia rich fertilizers and often used as a measure of the health of water in natural bodies such as rivers or lakes, or in manmade water reservoirs. From the results obtained, all sampling points for AN level is in Class I under the NWQSM.



vii) Oil and Grease (OG)

The concentration of dispersed OG is an important parameter for water quality and safety. OG in water can cause formation of oil layer and shoreline deposits leading to environmental degradation, and can induce human health risks when discharged in surface or ground waters. This parameter aims to test whether in general there has been indiscriminate dumping of oils or oily waste into the water bodies. Both samples showed the level of oil and grease below measurable ranges (<1.5 mg/l) that indicates near natural background levels.



viii) Total Coliform Count (TCC)

The term TCC refers to a numerical count that generally includes both fecal and non-fecal coliforms, and is used to highlight bacterial contamination of the waters. Sampling points for W_1 and W_2 classified under Class I, and the rest of the sampling points TCC level are under Class IIA as stipulated in the NWQSM.

ix) Fecal Coliform Count (FCC)

The terms FCC refers to a subset numerical count of total coliform, primarily comprising fecal coliform bacteria that originate from the guts of warm-blooded animals and humans, and are used as an indicator of fecal matters. Based from the results, all sampling points FCC level are under Class IIB as stipulated in the NWQSM.

Synthesis of assessment

In general, the tests for water quality sampled from the various local rivers are considerably clean. One sampling point, W3, cannot be sampled due to the road has been blocked by fallen trees and thick forest. All rivers indicated no trace of oil and grease and harmful level of ammonium nitrate (indicator of extreme used of fertilizer). Total suspended solid levels and pH values generally complied with the standards set for water under Class I of the National Water Quality Standards for Malaysia, indicating impact of soil erosion is at the minimal level.

No indications of organic pollution in all sampling point as the BOD for all sampling point are under Class I of NQWSM. The amounts of COD in sampling points W4 and W5 are under Class III of NWQSM, while Class I and Class IIA each for W1 and W2 sampling point. Chemical Oxygen Demand (COD) is the amount of oxygen used to oxidize chemical substances through chemical processes. The result for sampling point W4 and W5 suggest that there is high chemical contamination in the sampling point and this need further study. For DO amounts all sampling points are under Class I and Class IIA of NQWSM. DO are essential for the aquatic life within the river water. A low DO level would threaten the aquatic community whereas only DO level below 2 mg/l is considered harmful for aquatic life.

Based on the total and faecal coliform counts, the bacterial contamination level in all sampling points are low and showing no sewerage problem. Only the sampling point W1 showing that the total FCC is equivalent to total TCC, this could indicate that people or mammals species has been using the previous point as waste dumping area. Although the TCC are showing elevated level in sampling point W4 and W5, this would indicate the source of microbes or coliform bacteria could

have originated from the soil, from plants and from other sources on the surface waters. Nevertheless, the river water would require conventional treatment such as boiling before it can be used for domestic consumption.

Water Quality Index (WQI)

The results of water quality index for W_1 to W_5 sampling points are listed in the table below.

Table 3. Water Quality Index for Sampling Points in Deramakot Forest Reserve

Sampling Location	DO%	BOD	COD	SS	pH	NH3-NL	SIDO	SI BOD	SI COD	SI AN	SI SS	pH SI	WQI	CLASS	WQ STATUS
W_1	93.06	1	17.7	16	7.51	0.09	100	96	76	91	88	97	92	II	CLEAN
W_2	90.88	1	25.6	9	7.18	0.05	97	96	68	95	92	99	91	II	CLEAN
W_3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
W_4	98.02	1	64	9	7.4	0.1	100	96	35	90	92	97	86	II	CLEAN
W_5	76.97	1	76.8	37	7.2	0.08	86	96	28	92	78	99	80	II	SLIGHTLY POLLUTED
AVERAGE	71.78	0.8	36.82	14.2	5.858	0.064	80	97	56	94	89	89	84	II	CLEAN

*NA = Not Available

Based on the river water quality index, all sampling point falls within Class II, categorized as Clean rivers. Comparing the river water quality index from the year before, the result shows that there's improvement for all sampling point except for W5 sampling point which show slightly deteriorated in WQI falls within Class II but categorized as Slightly Polluted river. All sampled rivers are categorized as clean water and able to use for human livelihood and consumption (Table 3).

For future undertaking, it is recommended that the management team to install signage in all river crossing areas to prevent visitors or passerby traversing from dumping waste into the watercourse. The management team should periodically brief departmental, adjacent communities and contract workers on this matter to protect the river water quality. The management also may need to carry out periodic inspection and monitoring on existing sewage and septic tanks in all office and living quarters within the FMU to prevent deterioration of the waste treatment system. As for future sampling for W1, we proposed it should be shifted further up-stream to compare the result and conclude whether the river are polluted with FCC or just the point of sampling is used as waste dumping area.

REFERENCES

Department Of Environment Malaysia (DOE), 2011. Malaysia Environmental Quality Report 2011. http://www.doe.gov.my/webportal/en/penerbitan-jas/

http://www.wepa-db.net/policies/law/malaysia/eq_surface.htm

APPENDIX I

METHODOLOGY

Sampling Method and Parameters Tested for Chemical Analyses

Grab sampling technique was used to collect all water samples. All samples were collected in a polyethylene and amber glass bottles for analysis. The samples were preserved accordingly and sent to Chemsain Konsultant Sdn. Bhd (an accredited laboratory), for analysis within 24 hours of collection. Parameters tested are according to the DOE Water Quality Index (WQI) with additional other physical and microbiological analysis of the waters. The parameters tested were concentration of hydrogen ion (pH), Biological Oxygen Demand (BOD in mg/l), Chemical Oxygen Demand (COD in mg/l), Ammoniacal Nitrogen (AN in mg/l), Suspended Solid (SS in mg/l), Dissolved Oxygen (DO in mg/l), fecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l). The results for all parameters tested by Chemsain Konsultant Sdn. Bhd are listed in Appendix II.

Water Quality Index

Water Quality Index (WQI) is used to determine the water quality status and to classify the rivers based on WQI and the Interim National Water Quality Standards for Malaysia (INWQSM). It also provides a convenient means of summarizing water quality data for sampled river water. The existing WQI equations are proposed by the Department of Environment Malaysia. DOE river water monitoring programme was practised in Malaysia since the year 1978. Water quality data were used to determine the water quality status weather in clean, slightly polluted or polluted category and to classify the rivers in Class I, II, III, IV or V based on Water Quality Index (WQI) and National Water Quality Standards for Malaysia (NWQS).

The results of the water quality sampling receive from Chemsain Konsultant Sdn. Bhd (an accredited laboratory) for sampling points namely W1 and W6 was calculated using the Water Quality Index (WQI) to determine the status and classify the rivers. The formulas used in the calculation of WQI are:

$$\mathbf{WQI = 0.22SIDO+0.19SIBOD+0.16SICOD+0.16SISS+0.15SIAN+0.12SI\ pH \quad (1)}$$

where, WQI = Water quality index; SIDO = Sub-index of DO; SIBOD = Sub-index of BOD; SICOD = Sub-index of COD; SIAN = Sub-index of AN; SISS = Sub-index of TSS; SIpH = Sub-index of pH.

Sub-index for DO (in % saturation):

SIDO	= 0 for	DO < 8	(2a)
	= 100 for	DO > 92	(2b)
	$= -0.395 + 0.030DO^2 - 0.00020DO^3$	for 8 < DO < 92	(2c)

Sub-index for BOD:

SIBOD	= 100.4 – 4.23BOD	for BOD < 5	(3a)
	$= 108e^{-0.055BOD} - 0.1BOD$	for BOD > 5	(3b)

Sub-index for COD:

SICOD	= -1.33COD + 99.1	for COD < 20	(4a)
	$= 103e^{-0.0157COD} - 0.04COD$	for COD > 20	(4b)

Sub-index for AN:

SIAN	$= 100.5 - 105AN$	for $AN < 0.3$	(5a)
	$= 94e^{-0.573AN} - 5 \mid AN - 2 \mid$	for $0.3 < AN < 4$	(5b)
	$= 0$	for $AN > 4$	(5c)

Sub-index for SS:

SISS	$= 97.5e^{-0.00676SS} + 0.05SS$	for $SS < 100$	(6a)
	$= 71e^{-0.0016SS} - 0.015SS$	for $100 < SS < 1000$	(6b)
	$= 0$	for $SS > 1000$	(6c)

Sub-index for pH:

SIpH	$= 17.2 - 17.2pH + 5.02pH^2$	for $pH < 5.5$	(7a)
	$= -242 + 95.5pH - 6.67pH^2$	for $5.5 < pH < 7$	(7b)
	$= -181 + 82.4pH - 6.05pH^2$	for $7 < pH < 8.75$	(7c)
	$= 536 - 77.0pH + 2.76pH^2$	for $pH > 8.75$	(7d)

APPENDIX II

National Water Quality Standards for Malaysia

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l	NATURAL LEVELS OR ABSENT	-	(0.06)	0.5	LEVELS ABOVE IV
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (IV)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l		200	-	80	
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	
NO_2	mg/l		0.4	0.4 (0.03)	-	
NO_3	mg/l		7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l		50	-	-	
SO_4	mg/l		250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l		-	-	-	
Gross-α	Bq/l		0.1	-	-	
Gross-β	Bq/l		1	-	-	
Ra-226	Bq/l		< 0.1	-	-	
Sr-90	Bq/l		< 1	-	-	
CCE	µg/l		500	-	-	-
MBAS/BAS	µg/l		500	5000 (200)	-	-
O & G (Mineral)	µg/l		40; N	N	-	-
O & G (Emulsified Edible)	µg/l		7000; N	N	-	-
PCB	µg/l		0.1	6 (0.05)	-	-
Phenol	µg/l		10	-	-	-
Aldrin/Dieldrin	µg/l		0.02	0.2 (0.01)	-	-
BHC	µg/l		2	9 (0.1)	-	-
Chlordane	µg/l		0.08	2 (0.02)	-	-
t-DDT	µg/l		0.1	(1)	-	-
Endosulfan	µg/l		10	-	-	-
Heptachlor/Epoxide	µg/l		0.05	0.9 (0.06)	-	-
Lindane	µg/l		2	3 (0.4)	-	-
2,4-D	µg/l		70	450	-	-
2,4,5-T	µg/l		10	160	-	-
2,4,5-TP	µg/l		4	850	-	-
Paraquat	µg/l		10	1800	-	-

National Water Quality Standards For Malaysia

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	µS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)[a]	5000 (20000)[a]	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

Notes :
N : No visible floatable materials or debris, no objectional odour or no objectional taste
* : Related parameters, only one recommended for use
** : Geometric mean
a : Maximum not to be exceeded

DOE Water Quality Index Classification

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 – 3	3 – 6	6 – 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	mg/l	> 7	5 – 7	3 – 5	1 – 3	< 1
pH	-	> 7	6 – 7	5 – 6	< 5	> 5
Total Suspended Solid	mg/l	< 25	25 – 50	50 – 150	150 – 300	> 300
Water Quality Index (WQI)		< 92.7	76.5 – 92.7	51.9 – 76.5	31.0 – 51.9	< 31.0

Water Classes And Uses

CLASS	USES
Class I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use with body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

DOE Water Quality Classification Based On Water Quality Index

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 - 100	80 - 90	0 - 79
Ammoniacal Nitrogen (NH_3-N)	92 - 100	71 - 91	0 - 70
Suspended Solids (SS)	76 - 100	70 - 75	0 - 69
Water Quality Index (WQI)	81 - 100	60 - 80	0 - 59