REPORT ON THE ASSESSMENT OF WATER QUALITY IN DERAMAKOT FOREST RESERVE 2014

by

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INTRODUCTION

Environmental baseline sampling was carried out to characterize the water quality of 5 rivers in Deramakot FR, namely Sg. Rawog, Sg. Mannan, Sg. Tangkulap Kecil, Sg. Balat and Sg. Deramakot as of 24th June 2014 (Table 1).

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 D1 to D5 (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 2.6.2.

Table 1 The geographical location and site description of water quality sampling in Deramakot SFM Project Area.

Sample Point No.	Location	Surrounding Condition	Prevailing Weather conditions (24 hours)	Date of Sampling	GPS Location	
					North	East
D1	Rawog River	Secondary forest	Clear weather during sampling, but raining heavily for duration of 1 hour, 15 hours prior to sampling period.	24/06/2014	05°26.223'	117°25.559'
D 2	Mannan River (Basecamp)	Secondary forest		24/06/2014	05°21.955'	117°26.239'
D 3	Tangkulap Kecil River	Secondary forest		24/06/2014	05°19.445'	117°22.113'
D 4	Balat River	Secondary forest		24/06/2014	05°19.556'	117°35.351'
D 5	Deramakot River	Secondary forest		24/06/2014	05°17'05.16"	117°32'35.47"

Drainage system

Low hills and undulating terrain predominates the Deramakot natural landscape of which five main tributaries of the major Kinabatangan River flow from the reserve, namely Sg. Rawog Besar, Sg. Tabalion Besar, Sg. Liningkong, Sg. Deramakot and Sg. Tangkulap Kecil.Eventually all the waters from these rivers drain to the Sulu Sea. The largest portion (approximately 189.95 km2) is the catchment of Sg. Rawog Besar located at the northern part of the reserve (Figure 2.6.1). The second largest catchment with approximately 80.08 km2 is Sg. Tabalion Besar that drained toward east of DFR into Kinabatangan through KTS area. Whereas Sg. Liningkong and Sg. Tangkulap catchment is approximately 69.65 km^2 and 50.72

km^2 are located in the western part of the reserve, respectively. Sg. Deramakot catchment is located at the south and is approximately 63.51 km^2. There is a few smaller rivers namely Sg. Arawon (22.05 km^2), Sg. Rago-rago (19.43 km^2), Sg. Balat River (16.91 km^2), Sg. Kukon Besar (11.88 km^2), Sg. Tiu-tiu (4.84 km^2), Sg. Karis-karis (3.81 km^2), Sg. Going Up (0.85 km^2)and several short un-named tributeries of Milian (4.54 km^2)and Kinabatangan (16.86 km^2), that equally important in providing water source to Kinabatangan and Milian rivers.

Table 2 The 17 sub-catchment areas in relation to the forest management zone in Deramakot FR, Sabah.

No.	Water Catchment Area (River Name)	Protection (Ha)	Production (Ha)	Community (Ha)	Total Area (Ha)
1	Arawon	1145	1060		2205
2	Balat	1	1673	18	1691
3	Deramakot	1323	5028		6351
4	Going Up		85		85
5	Karis-Karis		381		381
6	Kukon Besar		1187		1187
7	Liningkong	944	6021		6965
8	Rago-Rago		1943		1943
9	Rawog Besar	1225	17771		18995
10	Tabalion Besar	601	7407		8008
11	Tangkulap Kecil	89	4983		5072
12	Tiu-Tiu		483		483
13	Milian T1		130		130
14	Milian T2		237		237
15	Milian T3		87		87
16	Kinabatangan T1		1453		1453
17	Kinabatangan T2	233			233
	Total Area	**5561**	**49928**	**18**	**55507**

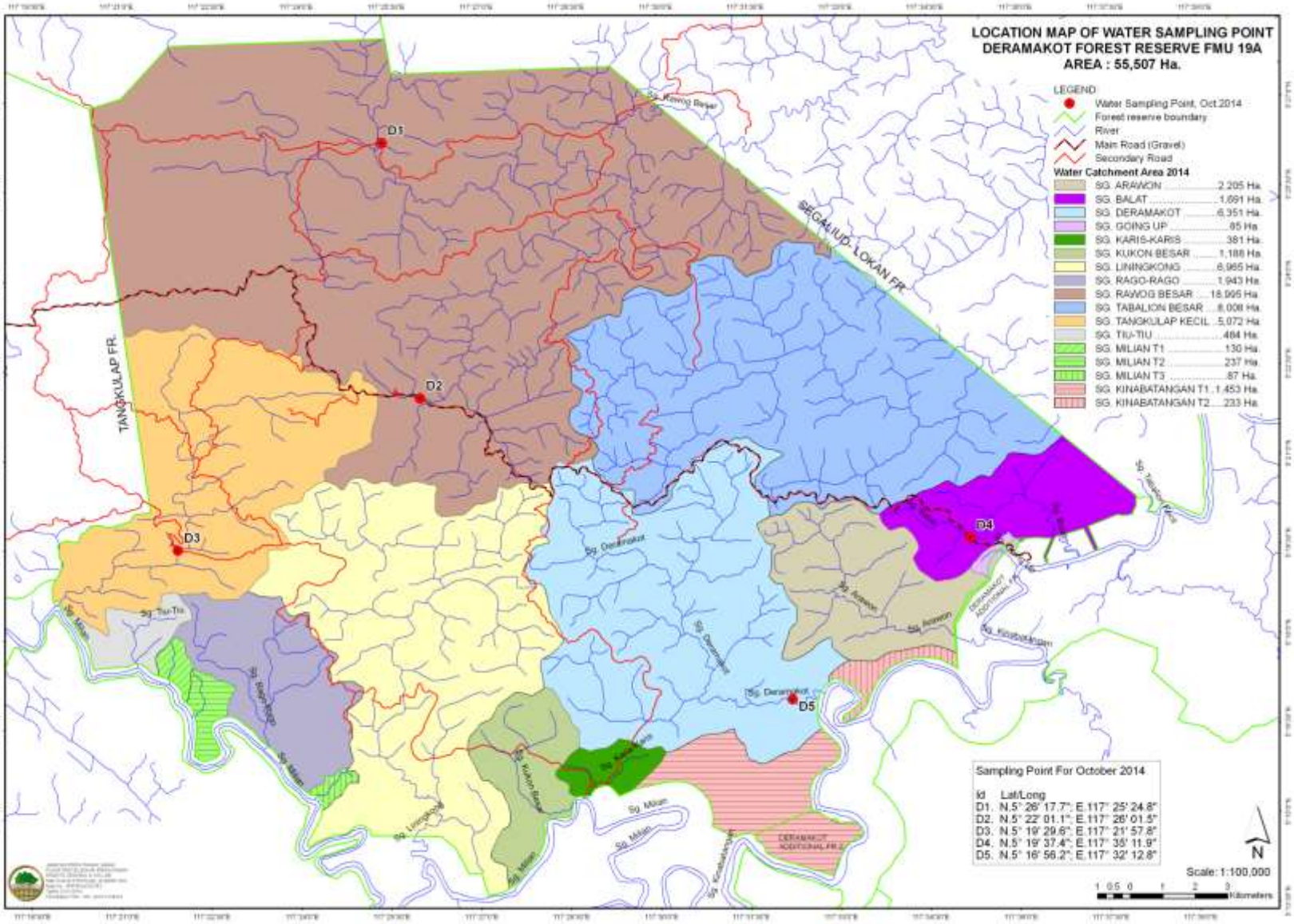

Figure 1 The distribution of 17 minor catchments found in Deramakot Forest Reserve, Sabah.

Water Quality

The chemical analyses and water quality classes for all parameters tested for the sampling points in the project area are listed in Table 3.

Table 3. The results of chemical analyses and water quality classes for all parameter tested for sampling location D1, D2, D3, D4, D5 in Deramakot Project Area. (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).

Parameters Tested	Sampling Location					NWQSM *
	D1	D2	D3	D4	D5	
Biological Oxygen Demand (BOD in mg/l)	<1.00	<1.00	<1.00	<1.00	<1.00	Class I for all sampling points
Suspended Solid (SS in mg/l)	57	8	33	7	31	D1: Class IIA D2 – D5 : Class I
Chemical Oxygen Demand (COD in mg/l)	25.6	25.6	25.6	19.2	32.0	D1,D2,D3& D5 : Class IIA D4 : Class I
Ammoniacal- Nitrogen (as N_3-N in mg/l)	<0.20	<0.20	<0.20	<0.20	<0.20	Class I for all sampling points
Dissolved Oxygen (DO in mg/l)	5.71	6.43	5.98	7.30	6.03	D1,D2,D3,D5 : Class IIA D4 : Class I
Oil & Grease (mg/l)	<1.50	<1.50	<1.50	<1.50	<1.50	Class I for all sampling points
Total Coliform Count (MPN/100mL)	9200	16000	9200	3500	9200	D1,D2,D3,D5 : Class IIB D4 : Class I
Fecal Coliform Count (MPN/100mL)	5400	1400	1700	3300	2400	Class IIB
pH value	7.07	6.89	7.26	7.52	7.14	Class I

∗ National Water Quality Standards for Malaysia

(i) pH Value

The concentration range of hydronium ions suitable for the existence of most biological life is narrow, typically between pH 6 to 9. The water pH levels for all five sampling points in Deramakot were ranged between 6.89 to 7.52 and could be classified under Class I water for the National Water Quality Standards for Malaysia (Table 2.6.2).

(ii) Suspended Solid

Suspended solid (SS) 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. All sampling point D2, D3, D4 and D5 registered SS levels categorized as Class I under the National Water Quality Standards for Malaysia (Table 2.6.2). Only D1 sampling point registered the highest SS levels and categorized as Class IIA. Part of the upper catchment of D1 is originated from oil palm estate that can be elucidated having low structural diversity that eventually may influence increase surface runoff and soil erosion during rainy season (Figure 2.6.1).

(iii) Biological Oxygen Demand (BOD)

This parameter is a measure to indicate the presence of organic waste in the river. All sampling points registered BOD levels within Class I under the National Water Quality Standards for Malaysia (Table 2.6.2).

(iv) Chemical Oxygen Demand (COD)

This parameter is an indicator of organics in the water and usually used in association with BOD. Four (4) sampling points registered COD levels as Class IIA under the National Water Quality Standards for Malaysia. Only D4 sampling point is classified under Class I (Table 2.6.2).

(v) Dissolved Oxygen (DO)

DO is an essential indicator in supporting aquatic life. It measures the amount of oxygen (O_2) that is dissolved in the water. Four (4) sampling points registered DO levels as Class IIA and one point (D4) under Class I as stipulated under the National Water Quality Standards for Malaysia (Table 2.6.2).

(vi) Ammoniacal-Nitrogen (as N_3-N)

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. All sampling points registered AN levels as Class I under the National Water Quality Standards for Malaysia (Table 2.6.2).

(vii) Oil and Grease

The presence of oil and grease in water bodies leads to the formation of oil layer, which causes significant pollution problem such as reduction of light penetration and photosynthesis. It further hinders oxygen transfer from atmosphere to water medium and this leads to decreased amount of dissolved oxygen (DO) at the bottom of the water thus adversely impacted of aquatic life in water. This parameter aims to test whether in general there has been indiscriminate dumping of oils or oily waste in to the water bodies. All five (5) sampling points in Deramakot showed levels of oil and grease below measurable ranges (<1.5 mg/l) that indicates near natural background levels (Table 2.6.2).

(viii) Total Coliform Count (TCC)

The term total coliform count (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. Four (4) sampling points in Deramakot registered TCC levels under Class IIB and one point (D4) under Class I as stipulated under the National Water Quality Standards for Malaysia (Table 2.6.2).

(ix) Fecal Coliform Count (FCC)

The term refers to a subset numerical count of total coliform, primarily comprising fecal coliform bacteria that originates from the guts of warm-blooded animals and humans, and is

used as an indicator of fecal matters. All the five (5) sampling points registered FCC levels for water under Class IIB of the National Water Quality Standards for Malaysia (Table 2.6.2).

In general, the tests for water quality sampled from the various local rivers are considerably clean (Table 2.6.3). 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 COD correlates with the DO and this shown in the result where four (4) sampling points are Class IIA and only one (D4) sampling point in Class I for both COD and DO result.

Although part of Rawog River derived from adjacent oil palm estate, there is no indication of excessive usage of ammonia rich fertilizers, shown by Ammoniacal- Nitrogen (as N_3-N) result which complied with the standards under Class I of the National Water Quality Standards for Malaysia.

Based on the total and faecal coliform counts, the bacterial contamination level in all sampling points are low and showing no sewerage problem especially in sampling point D2 where the Deramakot forestry office and living quarters are located. These results should be expected for rivers draining from catchment areas without forest harvesting activities. This favourable finding may elucidate that sustainable forest management practices in Deramakot could maintain or enhance environmental quality of the area even with timber extraction activities is on-going periodically. The water quality test will be conducted twice a year as monitoring tool for evaluating ecosystem services provided by the FMU.

Water Quality Index (WQI)

Table 3. The water quality index (WQI) for W1to W6 sampling points in Deramakot Project Area. (Note: DO % saturation values were calculated based on dissolved oxygen saturation factor of 8.26 mgL^{-1} at temperature 25° C).

Attributes	Sampling Point				
	D1	**D2**	**D3**	**D4**	**D5**
DO%	69.1	77.81	72.37	88.34	72.97
BOD	1	1	1	1	1
COD	25.6	25.6	25.6	19.2	32.0
SS	57	8	33	7	31
pH	7.07	6.89	7.26	7.52	7.14
NH3-NL	0.2	0.2	0.2	0.2	0.2
SIDO	77	87	81	96	82
SIBOD	96	96	96	96	96
SICOD	68	68	68	74	61
SIAN	80	80	80	80	80
SISS	69	93	80	93	81
SIpH	99	99	98	97	99
WQI	81	87	83	90	83
CLASS	**II**	**II**	**II**	**II**	**II**
WQ STATUS	**Clean**	**Clean**	**Clean**	**Clean**	**Clean**

All the river water was sampled on a clear weather, but raining heavily for duration of 1 hour, 15 hours prior to sampling period. Based on the river water quality index, all sampling point D1 to D5 falls within Class II and categorized as clean river. It is recommended that the management team to install signage to warn people not to drink raw waters from all the rivers as it would require conventional treatment such as boiling before it can be used for domestic consumption.

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 PHOTO GALLERY

PHOTO.1. Sampling points D1, Sg. Rawog, sampling was done on a clear weather.

PHOTO.2. Sampling points D1, Road condition to Sg. Rawog river.

PHOTO.3. Sampling points D2, Sg. Mannan 1, sampling was done on a clear weather.

PHOTO.4. Sampling points D2, Road development camp site near Sg. Mannan.

PHOTO.5. Sampling point D3, Sg. Tangkulap, sampling was done on a clear weather.

PHOTO.6. Sampling point 3, Sg. Bangkulat waterfall.

PHOTO.7. Sampling point 4, Sg. Balat, sampling was done on a clear weather.

PHOTO.8. Sampling point 4, Sg. Balat river.

PHOTO.7. Sampling point 4, Sg. Deramakot, sampling was done by boat on a clear weather.

PHOTO.7. Sampling point 4, Sg. Deramakot, sampling was done by boat on a clear weather.

APPENDIX II WATER QUALITY RESULTS

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TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Customer	:	Jabatan Perhutanan Sabah PPP Sepilok, PS 1407, 90715 Sandakan, Sabah.	Lab No. Type (No.) of Sample Date Received Date of Report	: : : :	CK/CL405/1961/14 River Water (5) 25th June 2014 10th July 2014
Attn	:	Ms. Noor Azmizah Bt. Andaman	Service Order	:	-

Parameter(s)	D1 Date: 24/06/14 Time: 2.00 pm	D2 Date: 24/06/14 Time: 1.00 pm	*Test Method*
pH Value @ 25°C	7.07	6.89	*APHA 4500H+ B, 2012*
Biochemical Oxygen Demand in 5 days @ 20°C, mg/L	<1.00	<1.00	*APHA 5210 B & 4500-O G, 2012*
Suspended Solids, mg/L	57.0	8.00	*APHA 2540 D, 2012*
Dissolved Oxygen, mg/L	5.71	6.43	*APHA 4500-O G, 2012*
Oil & Grease, mg/L	<1.50	<1.50	*APHA 5520 B, 2012*
Chemical Oxygen Demand, mg/L	25.6	25.6	*APHA 5220 C, 2012*
Ammoniacal-Nitrogen (as NH_3-N), mg/L	<0.20	<0.20	*APHA 4500-NH_3 C, 2005*

Parameter(s)	D3 Date: 24/06/14 Time: 3.50 pm	D4 Date: 24/06/14 Time: 12.00 pm	*Test Method*
pH Value @ 25°C	7.26	7.52	*APHA 4500H+ B, 2012*
Biochemical Oxygen Demand in 5 days @ 20°C, mg/L	<1.00	<1.00	*APHA 5210 B & 4500-O G, 2012*
Suspended Solids, mg/L	33.0	7.00	*APHA 2540 D, 2012*
Dissolved Oxygen, mg/L	5.98	7.30	*APHA 4500-O G, 2012*
Oil & Grease, mg/L	<1.50	<1.50	*APHA 5520 B, 2012*
Chemical Oxygen Demand, mg/L	25.6	19.2	*APHA 5220 C, 2012*
Ammoniacal-Nitrogen (as NH_3-N), mg/L	<0.20	<0.20	*APHA 4500-NH_3 C, 2005*

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TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Lab No.: CK/CL405/1961/14

Parameter(s)	D5 Date: 24/06/14 Time: 9.30 am	*Test Method*
pH Value @ 25°C	7.14	*APHA 4500H+ B, 2012*
Biochemical Oxygen Demand in 5 days @ 20°C, mg/L	<1.00	*APHA 5210 B & 4500-O G, 2012*
Suspended Solids, mg/L	31.0	*APHA 2540 D, 2012*
Dissolved Oxygen, mg/L	6.03	*APHA 4500-O G, 2012*
Oil & Grease, mg/L	<1.50	*APHA 5520 B, 2012*
Chemical Oxygen Demand, mg/L	32.0	*APHA 5220 C, 2012*
Ammoniacal-Nitrogen (as NH_3-N), mg/L	<0.20	*APHA 4500-NH_3 C, 2005*

Date of commencement of BOD_5 analysis: 25th June 2014

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Email: laboratory.kk@chemsain.com

TEST REPORT

* NOT FOR ADVERTISEMENT PURPOSES *

Customer	:	Jabatan Perhutanan Sabah PPP Sepilok, PS1407 90715 Sandakan, Sabah.	Lab No. Type (No.) of Sample Date Received Date of Report	: : : :	CK/ML405/1962/14 River Water (5) 25th June 2014 02nd July 2014
Attn	:	Ms. Noor Azmizah Bt Andaman	Service Order	:	-

Parameter	D1 Date: 24/06/14 Time: 2.00 pm	D2 Date: 24/06/14 Time: 1.00 pm	*Test Method*
Total Coliform Count MPN/100ml, 35±0.5°C/48 h	9.2×10^3	1.6×10^4	*APHA 9221B, 2012*
Fecal Coliform Count MPN/100ml, 44.5±0.2°C/24 h	5.4×10^3	1.4×10^3	*APHA 9221E, 2005*

Parameter	D3 Date: 24/06/14 Time: 3.50 pm	D4 Date: 24/06/14 Time: 12.00 pm	*Test Method*
Total Coliform Count MPN/100ml, 35±0.5°C/48 h	9.2×10^3	3.5×10^3	*APHA 9221B, 2012*
Fecal Coliform Count MPN/100ml, 44.5±0.2°C/24 h	1.7×10^3	3.3×10^2	*APHA 9221E, 2005*

Parameter	D5 Date: 24/06/14 Time: 9.30 am	*Test Method*
Total Coliform Count MPN/100ml, 35±0.5°C/48 h	9.2×10^3	*APHA 9221B, 2012*
Fecal Coliform Count MPN/100ml, 44.5±0.2°C/24 h	2.4×10^3	*APHA 9221E, 2005*

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APPENDIX III

i. National Water Quality Standards For Malaysia
ii. Water Classes And Uses
iii. DOE Water Quality Classification Based On Water Quality Index
iv. DOE Water Quality Index Classification
v. WQI Formula And Calculation

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

APPENDIX III (i)

ANNEX

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III*	IV	V
Al	mg/l	↑	-	(0.06)	0.5	↑
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)	L
Pb	mg/l		0.05	0.02* (0.01)	5	E
Mn	mg/l		0.1	0.1	0.2	V
Hg	mg/l	N	0.001	0.004 (0.0001)	0.002	E
Ni	mg/l	A	0.05	0.9*	0.2	L
Se	mg/l	T	0.01	0.25 (0.04)	0.02	S
Ag	mg/l	U	0.05	0.0002	-	
Sn	mg/l	R	-	0.004	-	A
U	mg/l	A	-	-	-	B
Zn	mg/l	L	5	0.4*	2	O
B	mg/l		1	(3.4)	0.8	V
Cl	mg/l	L	200	-	80	E
Cl_2	mg/l	E	-	(0.02)	-	
CN	mg/l	V	0.02	0.06 (0.02)	-	
F	mg/l	E	1.5	10	1	
NO_2	mg/l	L	0.4	0.4 (0.03)	-	
NO_3	mg/l	S	7	-	5	IV
P	mg/l		0.2	0.1	-	
Silica	mg/l	O	50	-	-	
SO_4	mg/l	R	250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l	A	-	-	-	
Gross-α	Bq/l	B	0.1	-	-	
Gross-β	Bq/l	S	1	-	-	
Ra-226	Bq/l	E	< 0.1	-	-	
Sr-90	Bq/l	N	< 1	-	-	↓
CCE	µg/l	T	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	-	-

Notes :

* = At hardness 50 mg/l $CaCO_3$
\# = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

APPENDIX III (i & ii)

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

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.

APPENDIX III (iii & iv)

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

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	-	> 7.0	6.0 – 7.0	5.0 – 6.0	< 5.0	> 5.0
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

APPENDIX III (v)

WQI FORMULA AND CALCULATION

FORMULA

WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)

where;

SIDO = Subindex DO (% saturation)
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH_3-N
SISS = Subindex SS
SIpH = Subindex pH
$0 \leq WQI \leq 100$

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES

Subindex for DO (in % saturation)

SIDO = 0	for $x \leq 8$
SIDO = 100	for $x \geq 92$
$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$	for $8 < x < 92$

Subindex for BOD

SIBOD = 100.4 - 4.23x	for $x \leq 5$
SIBOD = 108 * exp(-0.055x) - 0.1x	for $x > 5$

Subindex for COD

SICOD = -1.33x + 99.1	for $x \leq 20$
SICOD = 103 * exp(-0.0157x) - 0.04x	for $x > 20$

Subindex for NH_3-N

SIAN = 100.5 - 105x	for $x \leq 0.3$
SIAN = 94 * exp(-0.573x) - 5 * | x – 2 |	for $0.3 < x < 4$
SIAN = 0	for $x \geq 4$

Subindex for SS

SISS = 97.5 * exp(-0.00676x) + 0.05x	for $x \leq 100$
SISS = 71 * exp(-0.0061x) - 0.015x	for $100 < x < 1000$
SISS = 0	for $x \geq 1000$

Subindex for pH

$SIpH = 17.2 - 17.2x + 5.02x^2$	for $x < 5.5$
$SIpH = -242 + 95.5x - 6.67x^2$	for $5.5 \leq x < 7$
$SIpH = -181 + 82.4x - 6.05x^2$	for $7 \leq x < 8.75$
$SIpH = 536 - 77.0x + 2.76x^2$	for $x \geq 8.75$

Note:
* means multiply with