

WATER QUALITY ASSESSMENT IN DERAMAKOT FOREST RESERVE AND TANGKULAP FOREST RESERVE 2024

by

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INTRODUCTION

A water quality assessment was carried out by the Deramakot FMU staff to assess the quality of rivers in Deramakot FR (CPT 54, CPT 66 and CPT 105) and rivers in Tangkulap FR (CPT 60). The samples were analysed by Chemsains Konsultant Sdn. This report is providing the results and discussion of water quality as part of the environmental monitoring component for the Deramakot Sustainable Forest Management Project area.

LOCATION OF STUDY AREA

A total of 4 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 W4 (Table 1, Figure 1). Three of the headwaters of these rivers derived from within Deramakot itself and one from Tangkulap FR. 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 location of water sampling point 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

Sampling Point	Location	GPS location		Date of Sampling	Surrounding Condition
		Latitude	Longitude		
W1	CPT 54 Sg. Kun-Kun	N 05° 29' 22.53"	E 117° 11' 35.14"	April 2024	Secondary forest
W2	CPT 60 Sg. Mannan	N 05° 22' 01.99"	E 117° 25' 29.87"		Secondary forest
W3	CPT 66 Sg. Tabalion	N 05° 21' 51.16"	E 117° 32' 01.11"		Secondary forest
W4	CPT 105 Sg. Balat	N 05° 20' 06.30"	E 117° 33' 50.04"		Secondary forest

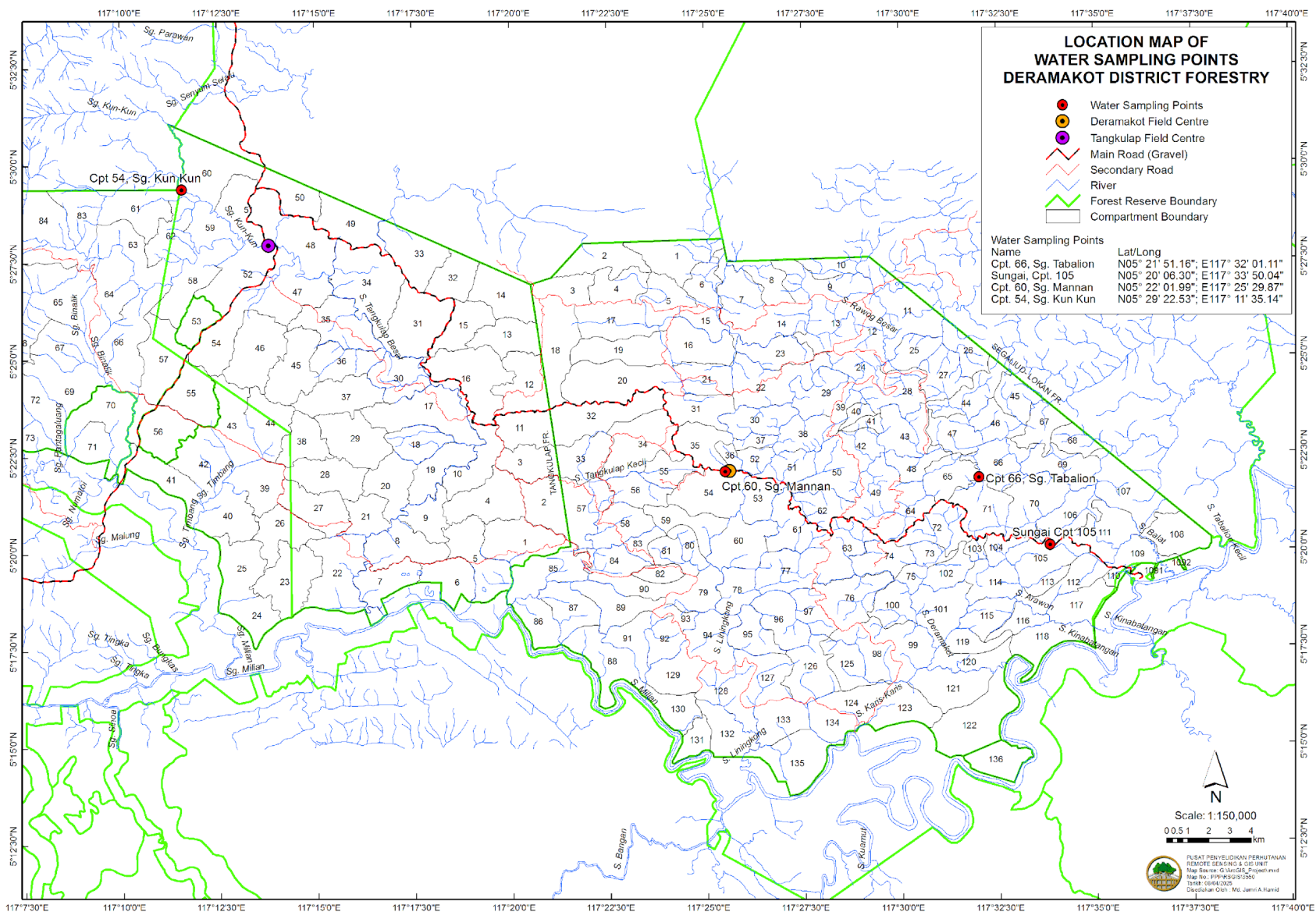


Figure 1

The location of 4 water sampling points W1 – W4 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 in DFR Project Area.
Note: Dissolved Oxygen (DO in mg/l), Conductivity ($\mu\text{S}/\text{cm}$), Total Dissolved Solid (TDS in mg/l), and Temperature ($^{\circ}\text{C}$).

Sampling Location		Dissolved Oxygen, DO (mg/l)	Biological Oxygen Demand	Chemical Oxygen Demand	Suspended Solid	pH Value	Ammoniacal-Nitrogen (as N3-N in mg/l)	Oil & Grease (mg/l)	Total Coliform Count (MPN/100mL)	Fecal Coliform Count (MPN/100mL)
CPT 54 Sg. Mannan	W ₁	5.0	1.0	24.2	5.0	6.6	0.05	1.5	2400	110
CPT 60 Sg. Kun-kun	W ₂	5.8	1.0	10.00	5.0	7.7	0.20	1.5	2400	790
CPT 66 Sg. Tabalion	W ₃	4.4	1.0	12.9	5.0	7.2	0.05	1.5	230	130
CPT 105 Sg. Balat	W ₄	4.5	1.0	14.5	5.0	7.0	0.05	1.5	16000	330
NWQSM*		W1 & W2 : Class IIB W3-W4 : Class III	Class I	Class I	Class I	Class I	Class I	NA	W1-W3: Class I W4 : Class IIB	W1, W3 & W4 : Class IIA W2 : Class IIB

DISCUSSION

Dissolved Oxygen (DO)

DO is an essential indicator in supporting aquatic life. It measures the amount of oxygen (O₂) that is dissolved in the water (Table 2). Sampling points W1 and W2 registered DO levels as Class IIB and W3 and W4 sampling points in Class III under the National Water Quality Standards for Malaysia.

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).

Chemical Oxygen Demand (COD)

This parameter is an indicator of organics in the water and is usually used in association with BOD. All sampling points are classified under Class I (Table 2) of the National Water Quality Standards for Malaysia.

Total Suspended Solid

TSS is an indicator of the amount of land disturbance within the catchment area and relates to the erosion that took place nearby the sampling area or upstream. All sampling points registered under Class I of the NWQSM.

pH Value

Based on the National Water Quality Standards for Malaysia, the pH level for all sampling points is classified within the Class I water quality range (Table 2). The narrow concentration of hydrogen ions between pH 6 to 9 indicates the typical suitability range for the existence of most biological life.

Ammoniacal- Nitrogen (as N₃N)

This parameter is an indicator of pollution from excessive usage of ammonia-rich fertilizers and is used as a measure of the health of the water in natural bodies such as rivers or lakes, or in manmade water reservoirs. All sampling points registered levels of AN as Class I under the National Water Quality Standards for Malaysia (Table 2).

Oil and Grease

This parameter aims to test whether there has been indiscriminate dumping of oil or oily waste into the water systems. All sampled showed levels of oil and grease below measurable ranges (<1.5 mg/l) and reflect near-natural reference levels (Table 2).

Total Coliform Count (TCC)

The term total coliform count (TCC) refers to a numerical count that generally includes both faecal and non-faecal coliforms, and the observation is used to highlight bacterial contamination of the waters. Sampling points W1, W2 and W3 registered TCC levels under Class I. For sampling point W4 it shows elevated levels as Class IIB under the National Water Quality Standards for Malaysia.

Faecal Coliform Count (FCC)

The term refers to a subset numerical count of total coliform, primarily comprising faecal coliforms bacteria, that originates from the guts of warm-blooded animals and humans. The observation is used as an indicator of faecal matters. All sampling point, registered FCC levels within Class IIA and Class IIB under the National Water Quality Standards for Malaysia.

Synthesis of assessment

In general, the tests for water quality sampling from the various local rivers are characterised by clean water quality (Table 3), status. The pH for all rivers generally complied with the standards set for water under Class I of the NQWSM. The pHs for all sampling points are within an acceptable limit.

All rivers indicated no trace of oil and grease and harmful levels of ammonium nitrate (an indicator of extremely used fertilizer). There is no indication of excessive usage of ammonia-rich fertilizers, shown by Ammoniacal- Nitrogen (as N₃-N) result which complied with the standards under Class I of the National Water Quality Standards for Malaysia. For total suspended solid, all sampling point generally complied with the standards set for water under Class I of the National Water Quality Standards for Malaysia, indicating the impact of soil erosion is at a minimal level. No indications of organic pollution in all sampling points as the BOD for all sampling points are under Class II of NQWSM. For DO amounts, sampling points W3 and W4 shows elevated levels for DO with Class III of NQWSM. Other sampling points show Class IIB of NQWSM. DO are essential for the aquatic life within the river water. A low DO level would threaten the aquatic community.

Based on the total and faecal coliform counts, the bacterial contamination level in all sampling points are low and shows no sewerage problem. Elevated levels of TCC sampled for waters at W4, was however represented by low FCC. 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. Elevated level of TCC and FCC could indicate the presence of potentially harmful viruses, bacteria or parasites within the water. The waters from these rivers would require pre-treating beyond simple boiling of the water before consumption. Bathing within these waters during periods of drought should also be avoided.

Water Quality Index (WQI)

The results of water quality index for W1 to W4 sampling points are listed in Table 3.

Table 3. The water quality index (WQI) for W1 to W4 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			
	W1	W2	W3	W4
DO%	60.51	70.19	53.25	54.46
BOD	1	1	1	1
COD	24.2	10	12.9	14.5
SS	5	5	5	5
pH	6.6	7.7	7.2	7
NH3-NL	0.05	0.2	0.05	0.05
SIDO	65	78	54	56
SIBOD	96	96	96	96
SICOD	69	86	82	80
SIAN	95	80	95	95
SISS	95	95	95	95
SIpH	98	95	99	99
WQI	85	88	85	85
CLASS	II	II	II	II
WQ STATUS	C	C	C	C

Based on the river water quality index, all sampling points falls within clean water quality status Class II. For sampling point W4, TCC result show higher result. It is recommended that the management team to install signage at all sampling point to prevent people from dumping waste into the watercourse. Furthermore, the management should periodically brief departmental and contract workers on this matter and protect the quality of water in the River. 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.

REFERENCES

Department Of Environment Malaysia (DOE), 2023. Environmental Quality Report 2023.

<https://edl.doe.gov.my/epub?p=wV8DYR82bhST8C07kZFtKBdrIOgtLofbxlrgQYcGHdXTmvjnXdf3AKbJ4BQlzVj0RPov2aWy%2b2KEHhYs3L9U%2bdKufBhWkNQIbSsoky7zpnL%2fbfcH%2b6PjXbd1GaVCRY0dvZJigxsqZe%2bJ42oehygBTQ%3d%3d>

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

APPENDIX I

METHODOLOGY

Sampling Method and Parameters Tested for Chemical Analyses

The grab sampling technique was used to collect water samples. All samples were preserved accordingly and sent to Chemsain Konsultant Sdn. Bhd (an accredited laboratory), company number 130904-U for analysis within 24 hours. Parameters tested are according to the DOE Water Quality Index (WQI) with additional other physical and microbiological analyses 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), faecal coliform (MPN/100mL), total coliform (MPN/100mL), and oil & grease (mg/l). The results for all parameters were 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 whether in the 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:

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

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):

$\text{SIDO} = 0$ for

$\text{DO} < 8$

(2a)

$$= 100 \text{ for } \text{DO} > 92 \quad (2b)$$

$$= -0.395 + 0.030\text{DO}^2 - 0.00020\text{DO}^3 \text{ for } 8 < \text{DO} < 92 \quad (2c)$$

Sub-index for BOD:

$$\text{SIBOD} = 100.4 - 4.23\text{BOD} \quad \text{for BOD} < 5 \quad (3a)$$

$$= 108e^{-0.055\text{BOD}} - 0.1\text{BOD} \quad \text{for BOD} > 5 \quad (3b)$$

Sub-index for COD:

$$\text{SICOD} = -1.33\text{COD} + 99.1 \quad \text{for COD} < 20 \quad (4a)$$

$$= 103e^{-0.0157\text{COD}} - 0.04\text{COD} \quad \text{for COD} > 20 \quad (4b)$$

Sub-index for AN:

$$\text{SIAN} = 100.5 - 105\text{AN} \quad \text{for AN} < 0.3 \quad (5a)$$

$$= 94e^{-0.573\text{AN}} - 5 | \text{AN} - 2 | \quad \text{for } 0.3 < \text{AN} < 4 \quad (5b)$$

$$= 0 \quad \text{for AN} > 4 \quad (5c)$$

Sub-index for SS:

$$\text{SISS} = 97.5e^{-0.00676\text{SS}} + 0.05\text{SS} \quad \text{for SS} < 100 \quad (6a)$$

$$= 71e^{-0.0016\text{SS}} - 0.015\text{SS} \quad \text{for } 100 < \text{SS} < 1000 \quad (6b)$$

$$= 0 \quad \text{for SS} > 1000 \quad (6c)$$

Sub-index for pH:

$$\text{SIpH} = 17.2 - 17.2\text{pH} + 5.02\text{pH}^2 \quad \text{for pH} < 5.5 \quad (7a)$$

$$= -242 + 95.5\text{pH} - 6.67\text{pH}^2 \quad \text{for } 5.5 < \text{pH} < 7 \quad (7b)$$

$$= -181 + 82.4\text{pH} - 6.05\text{pH}^2 \quad \text{for } 7 < \text{pH} < 8.75 \quad (7c)$$

$$= 536 - 77.0\text{pH} + 2.76\text{pH}^2 \quad \text{for pH} > 8.75 \quad (7d)$$

APPENDIX II

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

ANNEX II

ANNEX

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS				
		I	IIA/IB	III#	IV	V
Al	mg/l	-	-	(0.05)	0.5	LEVEL ABOVE IV
As	mg/l	0.05	0.1 (0.05)	0.1	-	
Ba	mg/l	1	-	-	-	
Cd	mg/l	0.01	0.01* (0.001)	0.01	-	
Cr(VI)	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	-	-	-	-	
/n	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	-	-	-	
CCF	mg/l	500	-	-	-	
MRAS/RMS	mg/l	500	5000 (200)	-	-	
O & C (Mineral)	mg/l	40; N	N	-	-	
O & C (Emulsified Edible)	mg/l	7000; N	N	-	-	
PCB	mg/l	0.1	6 (0.05)	-	-	
Phenol	mg/l	10	-	-	-	
Aldrin/Dieldrin	mg/l	0.02	0.2 (0.01)	-	-	
BHC	mg/l	2	9 (0.1)	-	-	
Chlordane	mg/l	0.08	2 (0.02)	-	-	
t-DDT	mg/l	0.1	(1)	-	-	
Endosulfan	mg/l	10	-	-	-	
Heptachlor/Epoxide	mg/l	0.05	0.9 (0.06)	-	-	
Lindane	mg/l	2	3 (0.4)	-	-	
2,4-D	mg/l	70	450	-	-	
2,4,5-T	mg/l	10	160	-	-	
2,4,5-TP	mg/l	4	850	-	-	
Paraquat	mg/l	10	1800	-	-	

Notes:

* – At hardness 50 mg/l CaCO₃

– Maximum (unbracketed) and 24-hour average (bracketed) concentrations

N = free from visible film sheen, discoloration and deposits

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	-	-	1000	-
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.

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	5.0 – 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

WQI FORMULA AND CALCULATION

Formula

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

where;

SIDO = Subindex DO (% saturation)

SIBOD = Subindex BOD

SICOD = Subindex COD

SIAN = Subindex NH₃-N

SISS = Subindex SS

SlpH = Subindex pH

0 ≤ WQI ≤ 100

Best Fit Equations for the Estimation of Various Subindex Values

Subindex for DO (in % saturation)

$$SIDO = 0$$

$$\text{for } x \leq 8$$

$$SIDO = 100$$

$$\text{for } x \geq 92$$

$$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$$

$$\text{for } 8 < x < 92$$

Subindex for BOD

$$SIBOD = 100.4 - 4.23x$$

$$\text{for } x \leq 5$$

$$SIBOD = 108 * \exp(-0.055x) - 0.1x$$

$$\text{for } x > 5$$

Subindex for COD

$$\begin{aligned} \text{SICOD} &= -1.33x + 99.1 && \text{for } x \leq 20 \\ \text{SICOD} &= 103 \cdot \exp(-0.0157x) - 0.04x && \text{for } x > 20 \end{aligned}$$

Subindex for NH_3 -N

$$\begin{aligned} \text{SIAN} &= 100.5 - 105x && \text{for } x \leq 0.3 \\ \text{SIAN} &= 94 \cdot \exp(-0.573x) - 5 \cdot |x - 2| && \text{for } 0.3 < x < 4 \\ \text{SIAN} &= 0 && \text{for } x \geq 4 \end{aligned}$$

Subindex for SS

$$\begin{aligned} \text{SISS} &= 97.5 \cdot \exp(-0.00676x) + 0.05x && \text{for } x \leq 100 \\ \text{SISS} &= 71 \cdot \exp(-0.0016x) - 0.015x && \text{for } 100 < x < 1000 \\ \text{SISS} &= 0 && \text{for } x \geq 1000 \end{aligned}$$

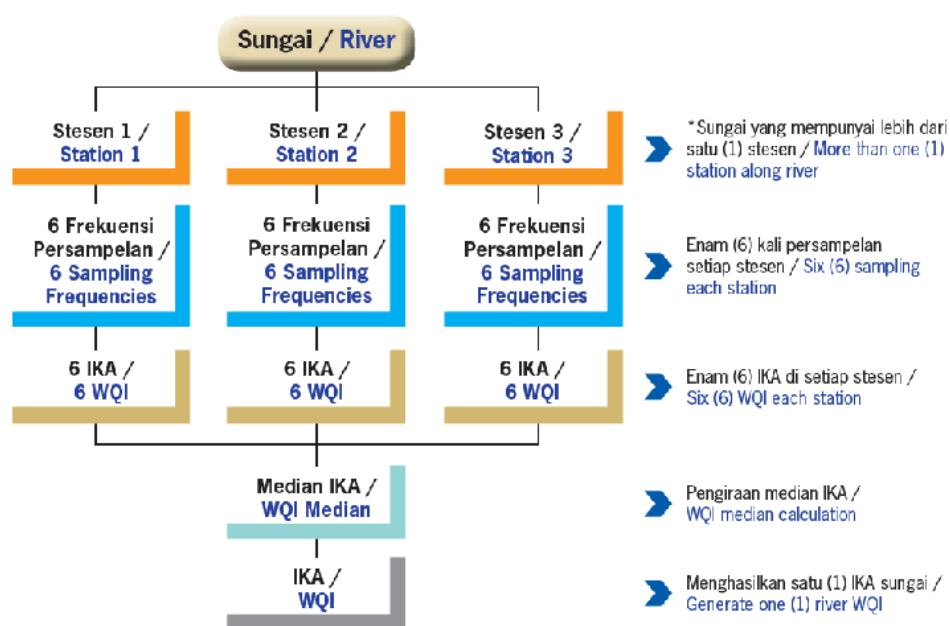
Subindex for pH

$$\begin{aligned} \text{SpH} &= 17.2 - 17.2x + 5.02x^2 && \text{for } x < 5.5 \\ \text{SpH} &= -242 + 95.5x - 6.67x^2 && \text{for } 5.5 \leq x < 7 \\ \text{SpH} &= -181 + 82.4x - 6.05x^2 && \text{for } 7 \leq x < 8.75 \\ \text{SpH} &= 536 - 77.0x + 2.76x^2 && \text{or } x \geq 8.75 \end{aligned}$$

Note:

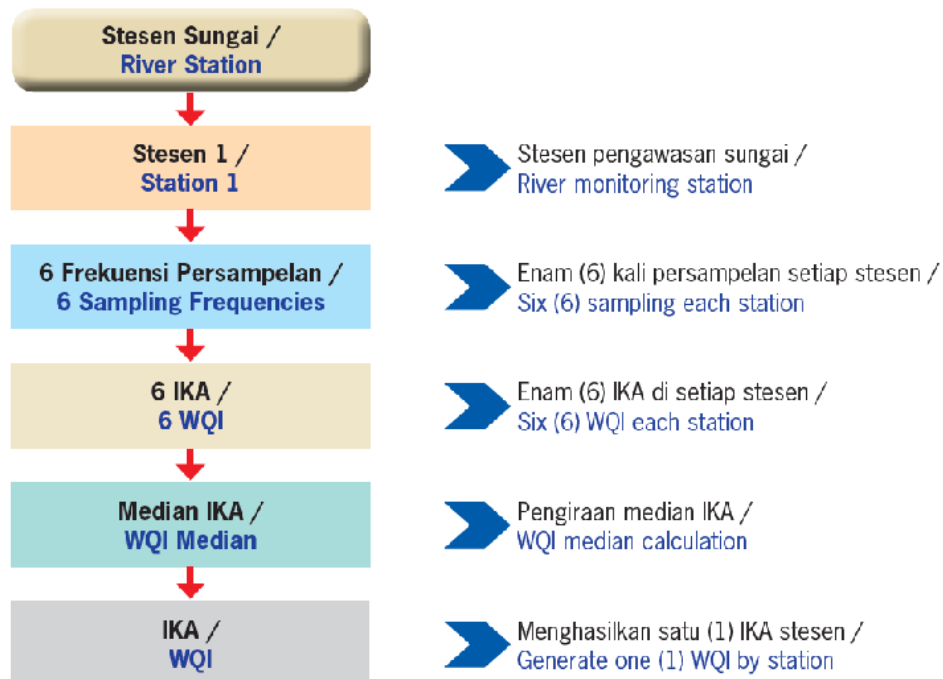
* means multiply with

PENENTUKAN INDEKS KUALITI AIR MENGIKUT SUNGAI /
DETERMINATION OF WATER QUALITY INDEX BY RIVER



* Bilangan stesen adalah berbeza mengikut sungai yang dipantau.
 Bagi contoh ini, pengiraan median adalah ke atas 18 data IKA /
 The number of stations varies according to the river monitored.
 For this example, the median calculation is on 18 WQI data

**PENENTUKAN INDEKS KUALITI AIR MENGIKUT STESEN /
DETERMINATION OF WATER QUALITY INDEX BY STATION**



**PENKELASAN SUNGAI
BERDASARKAN INDEKS
KUALITI AIR (IKA) /
RIVER CLASSIFICATION
BASED ON WATER QUALITY
INDEX (WQI)**

