"ENVIRONMENTAL MONITORING FOR SUSTAINABLE LAKE MANAGEMENT – IMPORTANCE AND CASE STUDY"

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Content

- Lakes, importance and threats
- Environmental monitoring
  - What, why
  - Lake Water quality monitoring
    - National Lake Water Quality Criteria and Standards (NLWQS)
    - Other monitoring
- Governance

LAKES – STANDING WATER SYSTEM

- NATURAL LAKES
- RESERVOIR
- EX-MINING POOLS
- RETENTION PONDS

LAKE AND RESERVOIR RESOURCES IN MALAYSIA

No.	State	Number	Area (km^2)	Volume (Mm^3)
1.	Perlis	2	13.33	40.00
2.	Kedah	7	105.63	1,384.76
3.	Perak	11	285.69	6,794.25
4.	Selangor	14	27.25	531.56
5.	Pahang	10	94.69	355.71
6.	Terengganu	2	370.80	13,600.00
7.	Kelantan	3	11.34	76.80
8.	Johor	13	108.26	986.24
9.	Labuan	3	1.20	4.58
10.	Melaka	4	11.41	78.60
11.	N. Sembilan	6	11.69	185.83
12.	P. Pinang	4	2.95	45.44
13.	Sabah	8	7.18	66.41
14.	Sarawak	7	793.74	46,496.88
15.	Wilayah Persekutuan	2	7.63	45.00
	Total	**96**	**1,852.79**	**70,692.06**

Excluding ox-bow lakes, ex-mining pools, bunded storage and flood detention pond

Source: NAHRIM (2014) Blueprint for Lake and reservoir Research

VALUE OF LAKE RESOURCES IN MALAYSIA

Domestic and industrial water supply

- Supply 98% of the total national water use
- > 60 reservoirs

Hydroelectric

- 16 reservoirs i.e. Kenyir, Bakun & Chenderoh Dam
- Contributing ~ 11% of total energy

Flood mitigation

- >12 reservoirs i.e. Timah Tasoh, Batu Dam, Semberong Dam, Bekok Dam & Machap Dam - reduced flooding risk

Source: NAHRIM (2014) Blueprint for Lake and reservoir Research

VALUE OF LAKE RESOURCES IN MALAYSIA

- **Irrigation**
  - > 10 reservoirs i.e. Bukit Merah, Muda, Pedu and Ahning Reservoir

Fishing and aquaculture

- Kenyir, Temenggor & Batang Ai Reservoir - Freshwater cage culture

- **Biodiversity**
  - Bera and Bukit Merah Reservoir: arowana
  - Numerous species of freshwater fish, plankton and flora

Source: NAHRIM (2014) Blueprint for Lake and reservoir Research

VALUE OF LAKE RESOURCES IN MALAYSIA

Recreation and tourism

- Amenity to urban populations
- Tourism

Heritage and patrimony

- Older lakes support community and cultural values

Source: NAHRIM (2014) Blueprint for Lake and reservoir Research

THREATS AND IMPACTS

Unsustainable Logging activities and land clearance

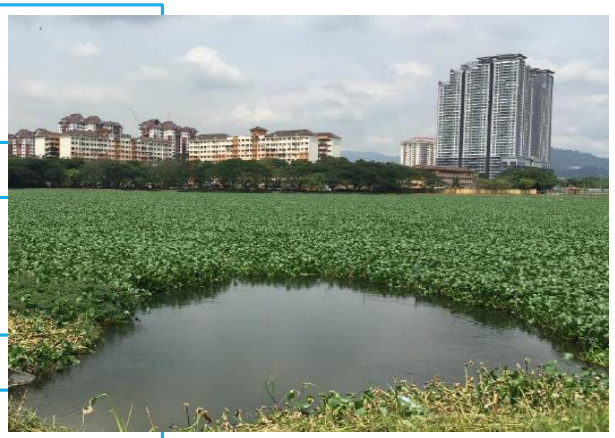
- Sediments, nutrient -> SEDIMENTATION/EUTROPHICATION

Urbanisation and inadequate treatment facilities

- Sewage, effluent discharges -> EUTROPHICATION / POLLUTION

Unsustainable agriculture /farming practices

- Nutrient, pesticides -> EUTROPHICATION / POLLUTION



Mining

- Heavy metals -> ACIDIFICATION / POLLUTION

Climate change & variability

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ENVIRONMENTAL MONITORING

WHAT AND WHY

WHAT IS ENVIRONMENTAL MONITORING

- The process of characterizing and observing environmental parameters
- To establish
  - The current status or conditions of the environment
  - The current trends in environmental parameters
  - The environmental issues i.e. pollution/ contaminants
  - Suitability for beneficial/intended uses

WHAT IS ENVIRONMENTAL MONITORING

- Water quality monitoring
  - Chemical
  - Biological & Microbiological
  - Radiological
  - Population
- Air quality monitoring
- Sediment/soil quality monitoring
- Noise monitoring

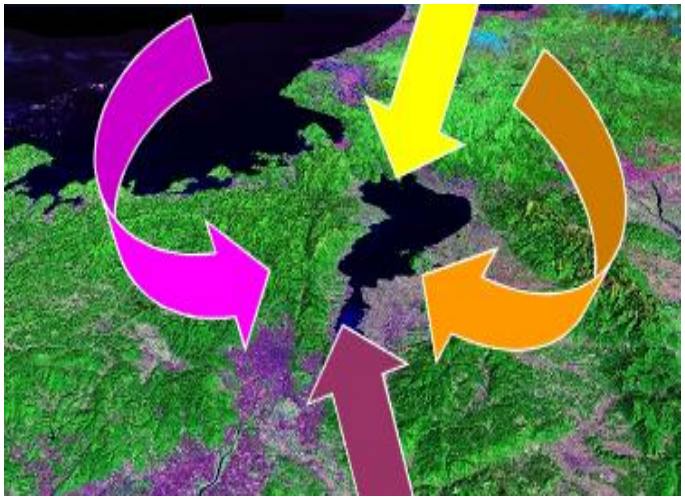
WHY MONITOR LAKE ENVIRONMENT

- Monitoring is crucial for informed decision making & management
- Enable better understanding of lake water quality state and catchment conditions
- Monitoring is lacking in many stagnant water bodies
- No specific agency monitoring lake water quality

THE NEED FOR LAKE MONITORING

‘Lentic’ Water Characteristics

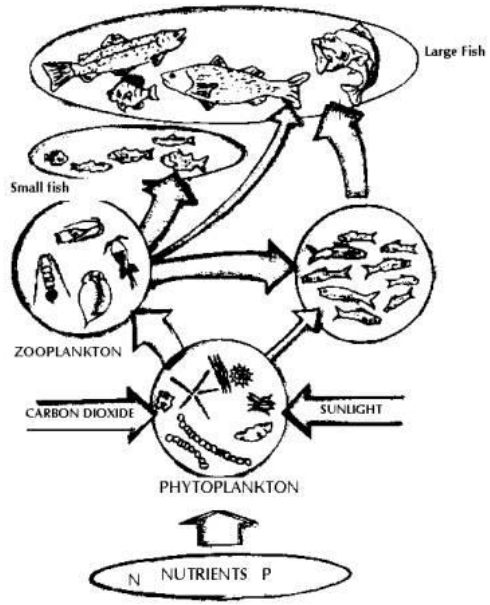
- Integrating Nature
- Long retention time – slow ecosystem changes (gradual & invisible)

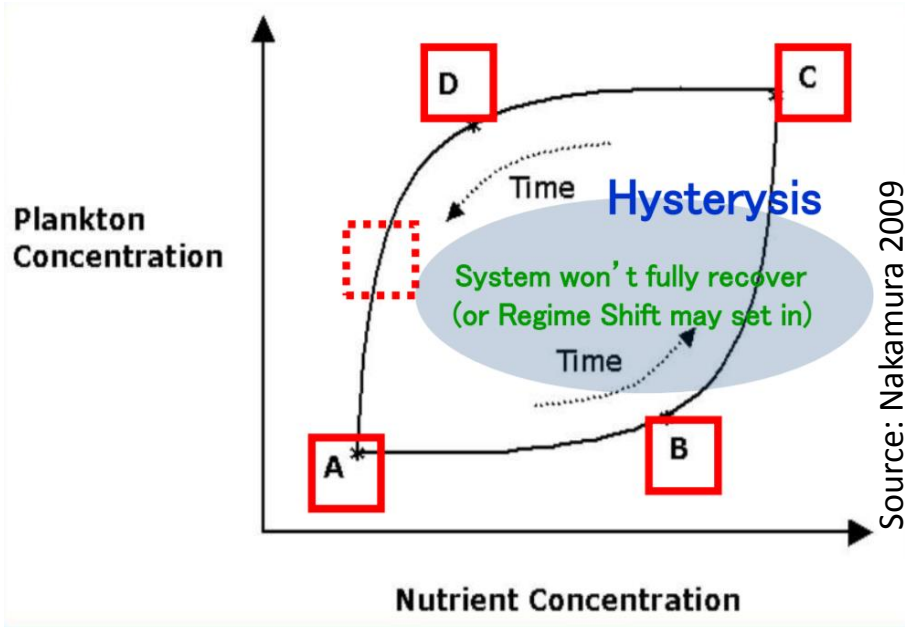


Source: Nakamura 2009

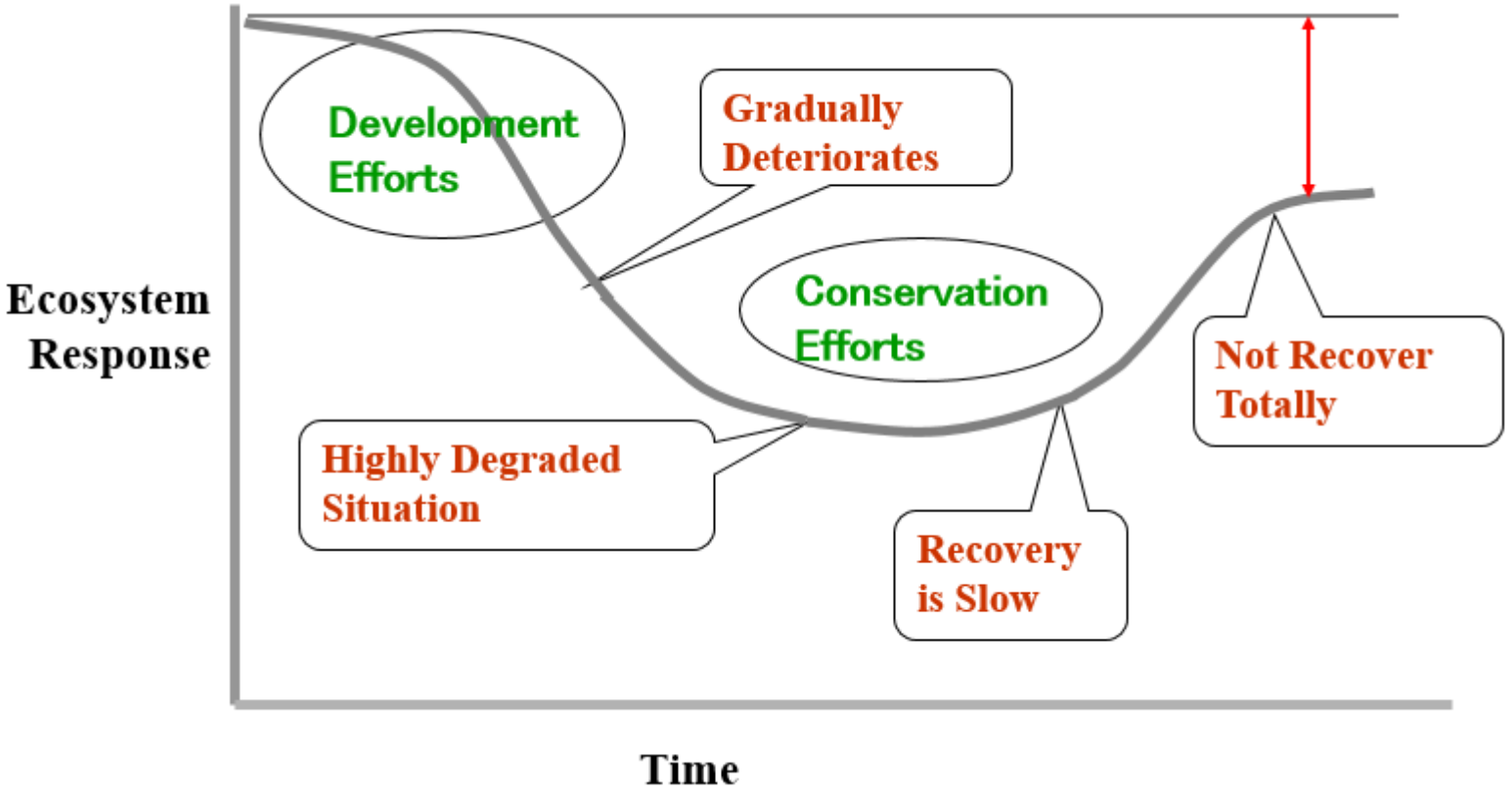
THE NEED FOR LAKE MONITORING

- 'Lentic' Water Characteristics (Cont')
  - Complex response dynamics – unpredictable & uncontrollable





THE NEED FOR LAKE MONITORING

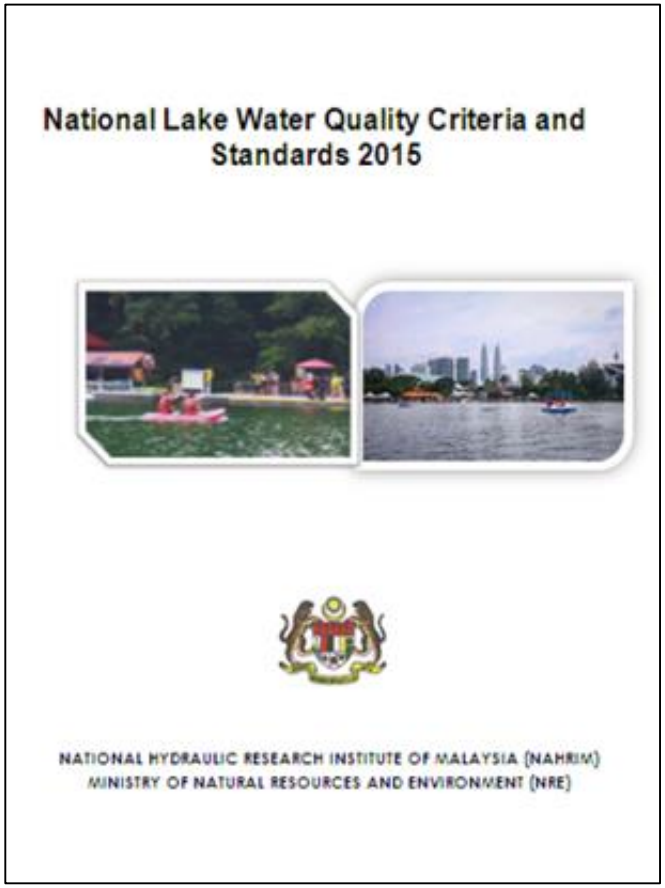


M. Nakamura, Professor, RCSE Shiga University, Vice President, ILEC Foundation, Japan, 2009

ENVIRONMENTAL MONITORING

WATER QUALITY

WATER QUALITY MONITORING



National Lake Water Quality Criteria and Standard (NLWQCS)

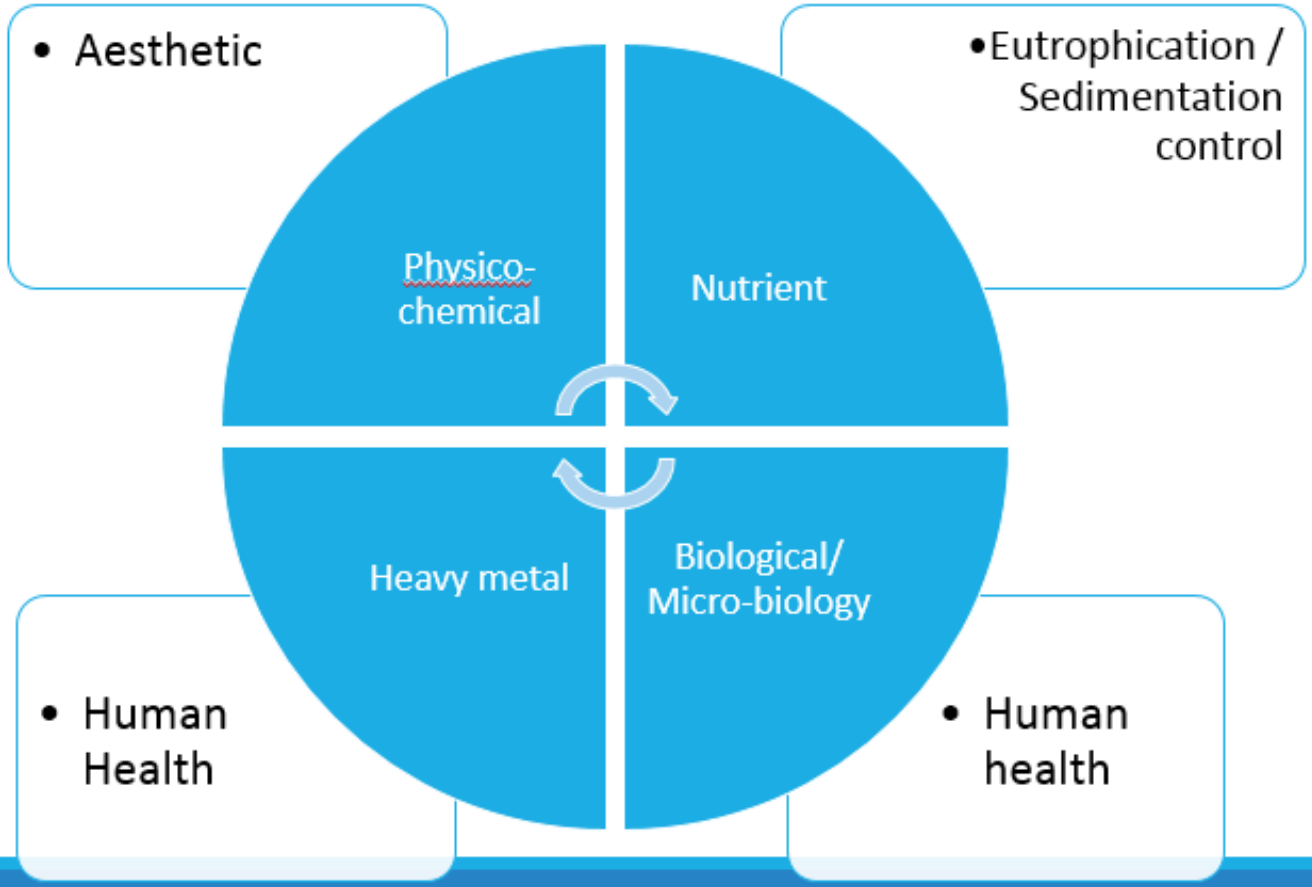
- Introduced in 2016 and accepted for use in 2017
- Focus on four category of uses
- Promote preservation of human health and ecosystem

www.nahrim.gov.my

National Lake Water Quality Criteria and Standards (NLWQS)

category	Uses
A	**Primary contact recreation** (contact - body, face with possible water been swallowed) – protect human health for recreational activities such as swimming
B	**Secondary contact recreation** – protect human health for recreational activities such as cruising and boating
C	**Preservation of freshwater ecosystem**
D	**Other uses and minimum preservation of ecosystem**

National Lake Water Quality Criteria and Standards (NLWQS)



National Lake Water Quality Criteria and Standards (NLWQS)

PARAMETER	UNIT	CATEGORY A	CATEGORY B	CATEGORY C	CATEGORY D
Temperature	°C	28 ± 3	28 ± 3	28 ± 3°	28 ± 3
Conductivity	µS/cm	1000	1000	2000	5000
DO percentage	%	80 -100	70 -110	55 - 130	40 - 130
Dissolved Oxygen	mg/L	6.3 - 7.8	5.5 - 8.7	4.5 – 10.3	3.3 – 10.3
pH	-	6.5 - 8.5	6.5 - 8.5	6.0 - 9.0	5.5 - 9.0
Floatables	-	NV	NV	NV	NV
Odour	-	NOO	NOO	NOO	NOO
Taste	-	NOT	NOT	NOT	NOT
Colour	TCU	100 - 200	150 - 300	300	300
TSS	mg/L	<100	100 - 500	200	500
Turbidity	NTU	40	40 - 170	70	250
Transparency (Secchi depth)	m	0.6	0.6	0.3	0.3
Oil & Grease	mg/L	1.5	1.5	1.5	1.5
Salinity	ppt	NVD	NVD	<1	>1
Ammonia-N	mg/L	0.1	0.3	1	2.7
Nitrate-N (NO_3-N)	mg/L	7	7	10	10
Total Phosphorus	mg/L	0.01	0.035	0.035	0.05
Chlorophyll-a	µg/L	10	3 – 15	15	25
Arsenic (As)	mg/L	0.05	0.1	0.15	0.4
Cadmium (Cd)	mg/L	0.002	0.002	0.01	0.01
Lead (Pb)	mg/L	0.05	0.05	0.05	0.05
Mercury (Hg)	mg/L	<0.001	<0.001	<0.0001	<0.001
Nickel (Ni)	mg/L	0.02	0.02	0.05	0.05

PARAMETER	UNIT	CATEGORY A	CATEGORY B	CATEGORY C	CATEGORY D
BOD	mg/L	3	6	6	8
COD	mg/L	10	25	25	50
Clostridium perfringens	-	nd	nd	nvd	nvd
Total Coliform	cfu/100ml	5000	5000	5000	5000
Enterococci	cfu/100ml	33	230	nvd	nvd
E. coli	cfu/100ml	100	600	3000	3000
Giardia sp.	-	nd	nd	nd	nd
Leptospira sp.	-	nd	nd	nd	nd
Cryptosporadium sp.	-	nd	nd	nd	nd
Cyanobacteria	Cells/ ml	15 000	15 000	15 000	15 000

Source: NAHRIM (2016)

Selected case studies – natural lake: Chini lake

PARAMETER	UNIT	Chini Lake
Temperature	°C	24.5
Conductivity	µS/cm	28
Dissolved Oxygen	mg/L	5.5
pH	-	3.5
BOD	mg/L	3.2
COD	mg/L	12.2
E. coli	CFU/100 ml	170
Enterococci	MPN/100 ml	-
Total coliform	CFU/100 ml	1674
TSS	mg/L	6.8
Turbidity	NTU	28.5
Transparency	m	0.5
Salinity	ppt	0.01
Ammonia-N	mg/L	0.3
Nitrate-N (NO_3-N)	mg/L	0.02
Total Phosphorus	mg/L	0.034
Chlorophyll-a	µg/L	2.8
Arsenic (As)	mg/L	<0.05
Cadmium (Cd)	mg/L	<0.001
Lead (Pb)	mg/L	0.05
Mercury (Hg)	mg/L	<0.001
Nickel (Ni)	mg/L	0.05
Cyanobacteria	Cells/ml	8.4
Remark		mesotrophic

Selected case studies – ex-mining pools: Puteri lake

PARAMETER	UNIT	Puteri Lake
Temperature	°C	30.5
Conductivity	µS/cm	795
Dissolved Oxygen	mg/L	6.4
pH	-	**3.0**
BOD	mg/L	0.9
COD	mg/L	1.4
E. coli	CFU/100 ml	-
Enterococci	MPN/100 ml	-
Total coliform	CFU/100 ml	-
TSS	mg/L	0.3
Turbidity	NTU	0
Transparency	m	**8.1**
Salinity	ppt	0.34
Ammonia-N	mg/L	0.05
Nitrate-N (NO_3-N)	mg/L	-
Total Phosphorus	mg/L	0.035
Chlorophyll-a	µg/L	<1
Arsenic (As)	mg/L	0.002
Cadmium (Cd)	mg/L	0.002
Lead (Pb)	mg/L	0.02
Mercury (Hg)	mg/L	-
Nickel (Ni)	mg/L	0.01
Cyanobacteria	Cells/ml	-
Remark		Acid-mine, low productivity

Selected case studies – flood retention pond: Intan baiduri lake


Photo: Sharip

PARAMETER	UNIT	Intan Baiduri
Temperature	°C	30.4
Conductivity	µS/cm	62
Dissolved Oxygen	mg/L	8.9
pH	-	8.2
BOD	mg/L	**22**
COD	mg/L	**132**
E. coli	CFU/100 ml	**2964**
Enterococci	MPN/100 ml	-
Total coliform	CFU/100 ml	**59267**
TSS	mg/L	60
Turbidity	NTU	45
Transparency	m	**0.2**
Salinity	ppt	0.13
Ammonia-N	mg/L	**1.09**
Nitrate-N (NO_3-N)	mg/L	0.03
Total Phosphorus	mg/L	**0.73**
Chlorophyll-a	µg/L	**51.5**
Arsenic (As)	mg/L	<0.01
Cadmium (Cd)	mg/L	0.002
Lead (Pb)	mg/L	0.04
Mercury (Hg)	mg/L	<0.001
Nickel (Ni)	mg/L	-
Cyanobacteria	Cells/ml	10,550
Remark		Hyper-eutrophic, organic pollutant

Selected case studies – flood mitigation/water supply reservoir: Sembrong Lake

PARAMETER	UNIT	Sembrong Lake
Temperature	°C	30.4
Conductivity	µS/cm	120
Dissolved Oxygen	mg/L	8.2
pH	-	8.1
BOD	mg/L	**12.8**
COD	mg/L	**50**
E. coli	CFU/100 ml	-
Enterococci	MPN/100 ml	-
Total coliform	CFU/100 ml	-
TSS	mg/L	15.6
Turbidity	NTU	25.5
Transparency	m	0.3
Salinity	ppt	0.01
Ammonia-N	mg/L	0.43
Nitrate-N (NO_3-N)	mg/L	n.d
Total Phosphorus	mg/L	**0.12**
Chlorophyll-a	µg/L	**65.4**
Arsenic (As)	mg/L	<0.01
Cadmium (Cd)	mg/L	<0.01
Lead (Pb)	mg/L	< 0.01
Mercury (Hg)	mg/L	<0.001
Nickel (Ni)	mg/L	< 0.01
Cyanobacteria	Cells/ml	**44070**
Remark		Hyper-eutrophic

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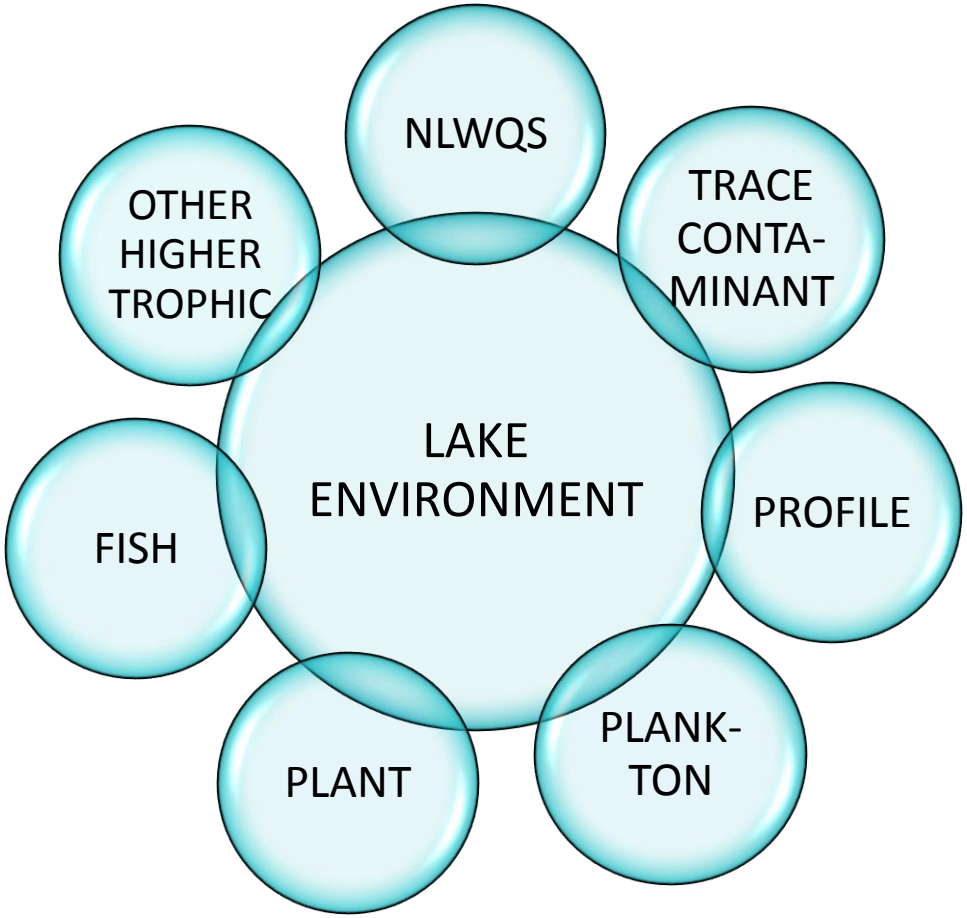
ENVIRONMENTAL MONITORING

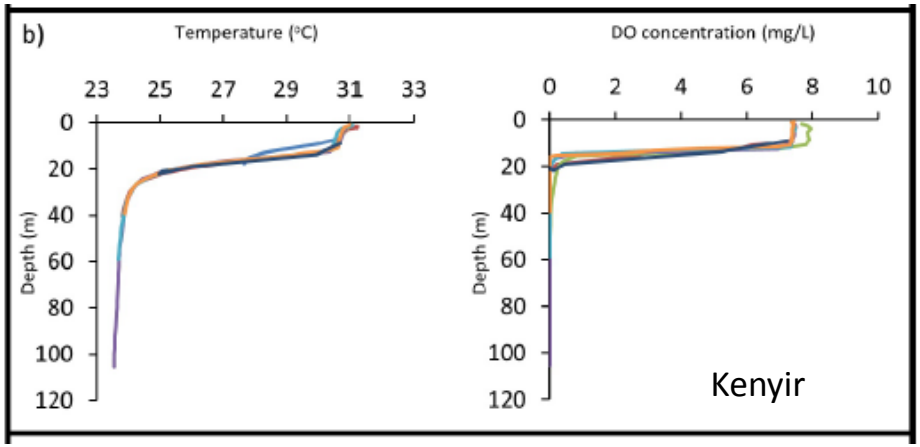
CONTAMINANTS AND BIOLOGICAL

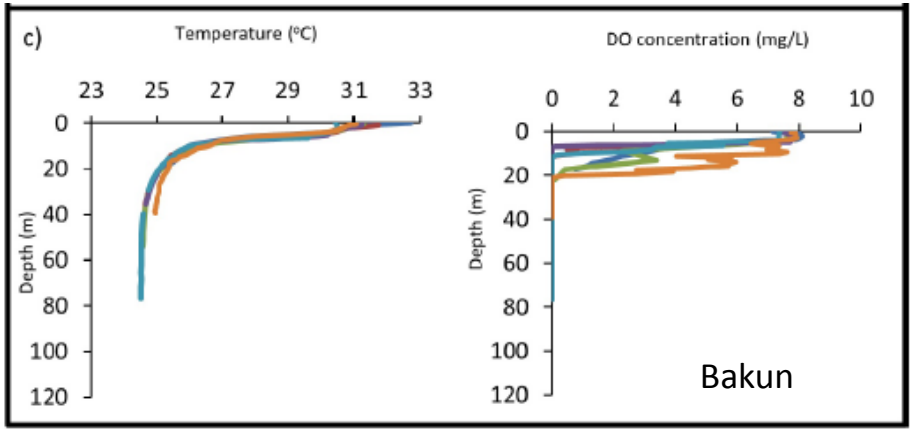
OTHER ENVIRONMENTAL MONITORING



MONITORING – STRATIFICATION PATTERN

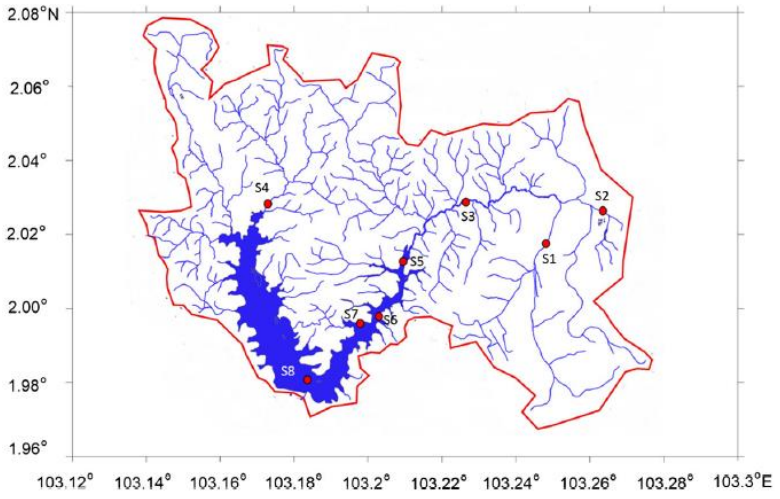
Stratification pattern in deep lakes of Malaysia





MONITORING – TRACE CONTAMINANTS

Agriculture areas



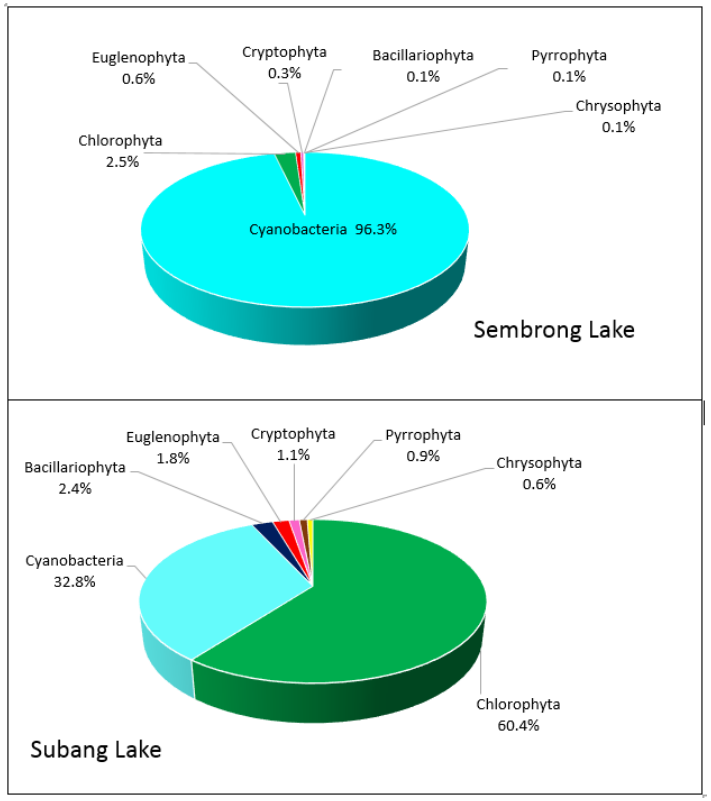
Organochlorine pesticides	Concentrations (ng/L)				Frequency of detection %
	Range	Mean	SD	NDWQS	
δ-BHC	0–23.0	2.26	4.65	2000	29.8
α-BHC	0–14.70	0.93	2.75	2000	14.9
γ-BHC	0–7.80	0.50	1.70	2000	12.8
β-BHC	0–14.90	0.55	2.52	2000	6.4
γ-Chlordane	0	0	0	200	0
α-Chlordane	0–23.50	0.76	3.66	200	8.5
Aldrin	0–50.40	3.17	9.42	30	27.7
Dieldrin	0–9.30	0.38	1.56	30	8.5
4,4-DDT	0–1873.60	40.44	273.22	2000	12.8
4,4-DDD	0–14.40	0.31	2.10	2000	2.1
4,4-DDE	0–12.70	0.29	1.86	2000	4.2
Endrin	0–51.40	2.78	8.30	600	21.2
Heptachlor	0–43.20	3.73	8.80	30	29.8
Heptachlor epoxide	0	0	0	30	0
Methoxychlor	0–234.70	14.33	48.20	20,000	27.7
α-Endosulfan	0–5.30	0.14	0.80	30,000	4.3
β-Endosulfan	0–121.5	3.22	17.88	30,000	6.4
Endrin aldehyde	0	0	0	600	0
Endosulfan sulphate	0–14.70	1.01	3.44	30,000	10.6

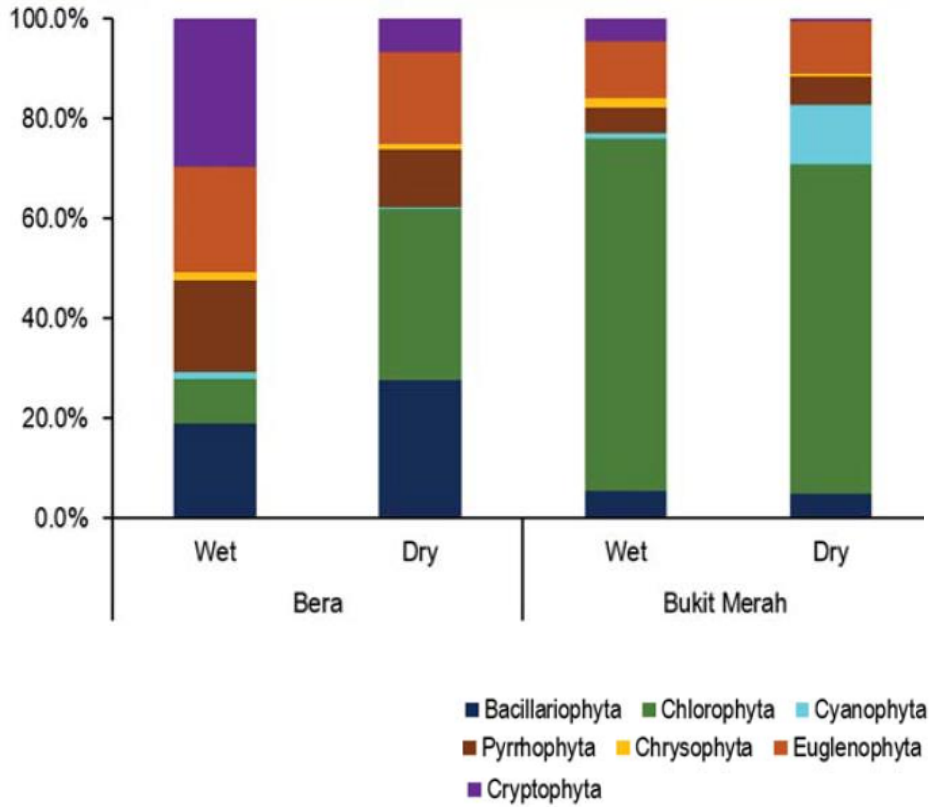
- Pesticides detected:
  - Aldrin/dieldrin, DDT, heptachlor, methoxychlor

Sharip et al. (2017) Occurrence of organochlorine pesticides…

PHYTOPLANKTON MONITORING

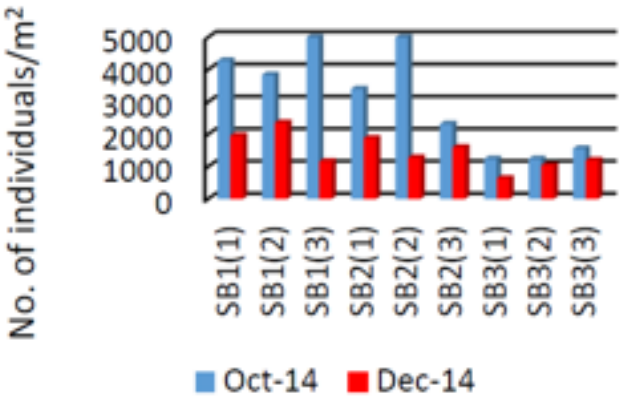
Comparison between lakes





Sharip & Yusoff (2017) Plankton community characteristics…

BENTHOS MONITORING




An aquatic worm (Oligochaeta), a tubificid (*Limnodrilus* sp)


An aquatic worm, a tubificid (*Branchiura* sp)

- consists mainly of *Chaoborus* and tubificid larvae - indicating eutrophic conditions
- increase of tubificid species is related to organic pollution

Source: Yusoff et al. (2017) A preliminary survey on benthic community…

PLANT MONITORING

- Characterising the ecological condition of lakes based on the composition of native and invasive plants growing
  - native plant community types and invasive plant species

- Invasive macrophyte

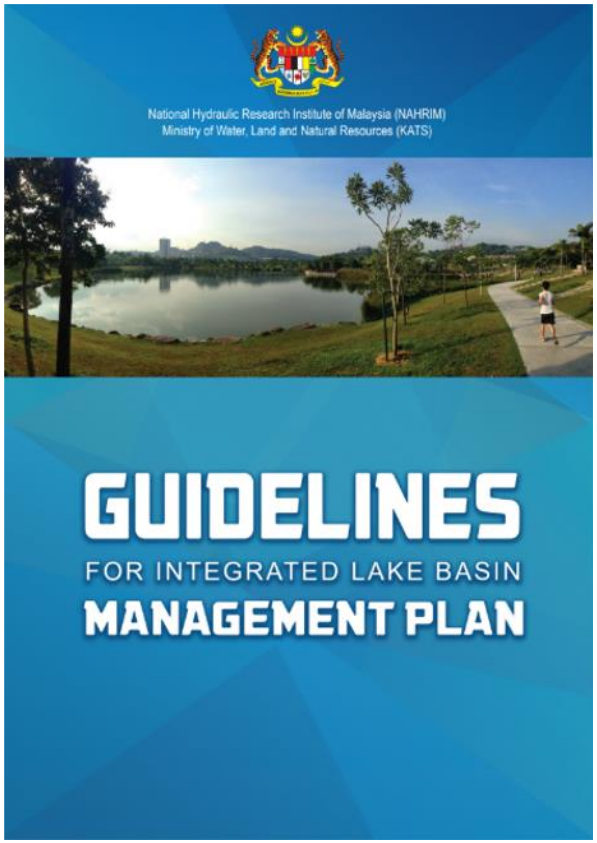
GOVERNANCE

MONITORING LINKS TO MANAGEMENT

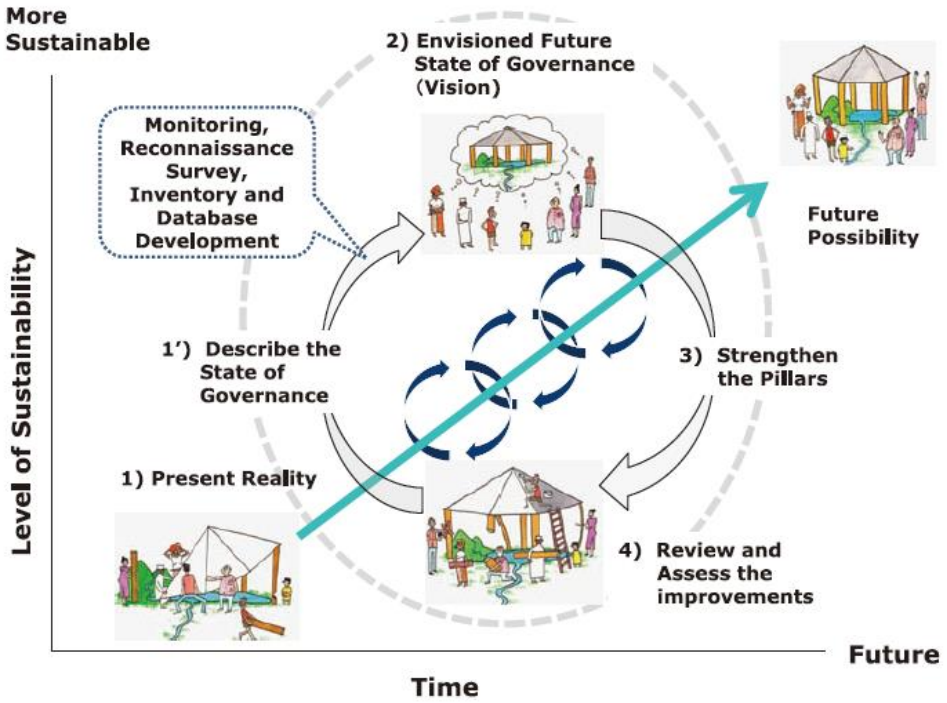
SUSTAINABLE MANAGEMENT OF LAKES

- monitor lake water quality and ecosystem health
- develop integrated lake basin management plan
- Continually assess governance improvement

MANAGEMENT & GOVERNANCE



NAHRIM (2018)



SDG Target 6: Ensure availability and sustainable management of water and sanitation for all:

Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all

Target 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

Target 6.5: By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

Target 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

Conclusion

- Lake environmental monitoring aid in management and protection of water bodies

- Use National Lake Water Quality Criteria and Standards for monitoring of water quality in lake/ponds/reservoir

THANK YOU

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