

Development of National Lake Water Quality Standards for Sustainable Management of Lakes and Reservoirs in Malaysia

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Abstract. Improving lakes and reservoir water quality throughout Malaysia is vital to ensure these water-bodies remain functional as its intended uses. However, identifying the quality of waterbodies remains a challenge due to inadequacy of specific criteria or monitoring standard for inland waterbodies and limited funding for testing. Developing a national lake water quality standard was identified as part of the national collective efforts to enhance water quality in these water bodies. Identification of parameters and limits for the standards, however, were limited by the availability of data and appropriate understanding of the characteristics of the waterbodies. The proposed standard may also pose challenges for improved water quality monitoring due to funding and technology limitation.

Keywords: Stakeholder consultations, water quality, standards, Malaysian lakes and reservoirs.

1. INTRODUCTION

Eutrophication of inland water is a prevalent issues in Malaysia impacting the ecosystem functioning of the lakes and reservoirs in the country. The preliminary study on the status of lake eutrophication reported that more 60% of the 90 lakes been studied were nutrient rich [1]. Few water supply reservoirs and urban lakes experienced algal bloom thus affecting human uses for drinking, recreation and aesthetic values [2]. Whilst other lakes faced macrophyte infestation and sedimentation problems. To address this widespread challenges, a strategic plan for sustainable management of lake was approved in 2012 for implementation [2, 3]. National Hydraulic Research Institute of Malaysia (NAHRIM), being the National Centre of Reference for Lake Research and Resources, is currently embarking in the development of the National Lake Water Quality Standard (NLWQS), being one of the action plans identified in Detailed Action Plan for Sustainable Lakes and Reservoir Management [4]. This work described the efforts that are being carried out in the development of the standard.

2. METHODOLOGY

This efforts were based on reviews of available standards in the literature covering various water quality standards in Malaysia and worldwide. Key literature document evaluated includes Interim National Water Quality Standards for Malaysia [5], Putrajaya Lake and Wetland Water Quality Standards [6], and National Standard for Drinking Water Quality [7]. In addition, questionnaires, stakeholder consultations and focus group meeting were identified to assess stakeholder needs. Reference was also made to other international standards such as WHO, US, EU, Japan and Australia [8-12].

3. RESULTS AND DISCUSSIONS

3.1. Proposed NLWQS

The development of the NLWQS aims to provide a tool that can be used by the stakeholder and lake owners to manage the lake or reservoir. The proposed standard which are divided into four (4) classes, was suggested as targets for respective lakes to achieve, as follows:

- Class A – primary body contact
- Class B – secondary body contact
- Class C – Protection of ecosystem
- Class D – Irrigation and general purposes

Class A and B were proposed for lakes that are used for recreational environment. Class A is for primary body contact such as bathing, diving, skiing and wind-surfing activities. Class B is for secondary body contact such as boating, cruising and angling. The main difference of the Class B compared to the Class A is that water borne disease parameters were not listed in the list of water quality standards. In Class A, heavy metals, pesticides and other toxicant were listed for control or management purposes.

Class C and D were proposed for lakes that are productive and meant for fisheries economic activities and irrigation respectively. Lakes having Class C and D are allowed to be more turbid and have higher concentration of TSS and nutrients, and lower transparency. The main difference of Class C and D is that oil and grease, and odour were not listed in the standard criteria.

A total of 26 parameters were identified as very important parameters for measurement. The main parameters identified include (i) physico-chemical parameters such as dissolved oxygen, pH, floatables, total suspended solids, turbidity, transparency, colour, biological oxygen demand, chemical oxygen demand, chlorophyll-a, oil and grease; (ii) nutrients such as nitrate, nitrite, ammonia, ammoniacal nitrogen and total phosphorus; (iii) microbial constituents such as pathogenic indicators namely faecal coliform, total coliform, enteroviruses and enterococci; and pathogens namely *Cryptosporidium* sp., *Leptospira* and *Giardia* sp.; and (iv) Total pesticides and total toxicant (including heavy metal) (Appendix 1). The listed parameters were more exhaustive but in-line with the proposed guidelines for water quality monitoring by the Ministry of Health [13]. However, nuisance algae, i.e. cyanobacteria, which is a major concern for eutrophic lakes was not included in the list of parameters.

Parameters that were listed as second list of importance or optional for measurement include temperature, odour, conductivity, hardness, taste and e-coli. Furthermore identified parameter need to be checked with actual data to develop basic standard and further validated with the international standard so that it can be used for effective management.

3.2. Stakeholder consultative sessions and way forward

Two stakeholder consultative sessions were carried out to refine the standards. Deliberation in the first stakeholder consultation identified the need for the standards to be based on actual data. There is also a need to consider the timing of the data collection, the weather and the characteristics of the lakes including depth that may affect the quality of the water. As of to date there are 26 lakes of which detail information on lakes were available and thus have been developed as lake brief [14-17]. More than 70 lakes (not inclusive of mining pools) were yet to be investigated as more information on these lakes need to be gathered. However, various researches have been undertaken by individual researchers throughout the country resulting to publication in impact journals. These publication can also be used as source of reference to assess the limits of the NLWQS parameters.

Financial issues to undertake the water testing were collectively identified by the stakeholders as major challenges for the implementation of the NLWQS. Water quality monitoring were usually performed based on the parameters to estimate the water quality index and Carlson's trophic state index due to limited of funds. Pathogenic parameters such as *Leptospira* and *Giardia* sp. are rarely monitored. Measurements were usually undertaken by respective departments when there are reported cases. Additionally, methods for testing of parameters to lower detection limits, such as trace chemicals, are not fully developed in Malaysia.



Figure 1 Stakeholder Consultations in the Development of National Lake Water Quality Standards

Deliberation in the second stakeholder consultation refined further the classification of the proposed NLWQS and the limits of the parameters. Additionally, the role of the standards were also discussed. The NLWQS will become the directional targets for research and management programme. The standards is proposed to be non-binding and gradually be improved as more information and data gathered by the stakeholders.

Further assessment need to be carried out on the classification and their parameters. To address this challenges, ongoing stakeholder consultations, survey and focus group meeting are being conducted with the aim to get consensus of what are achievable targets for NLWQS as well as to suggest functional data collection that can contribute towards sustainable management of lakes and reservoirs in Malaysia.

Conclusions

The importance of this work is to develop a standard that can be used for sustainable management of lakes and reservoirs in Malaysia. The development of such standard, however, may be limited by time constraint, fund allocation as well as expert knowledge and variability of environmental stress that is beyond human control. Additionally governing the standard with appropriate methodology is needed to ensure effective national standard for application.

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APPENDIX A. PROPOSED NATIONAL LAKE WATER QUALITY STANDARDS

RECOMMENDED NATIONAL LAKE WATER QUALITY STANDARD						
Parameter	Code	Unit	Class A	Class B	Class C	Class D
PHYSICO-CHEMICALS						
Color	1	TUC	100	150	300	300
Conductivity	2	µS/cm	1000	1000	1000	1000
Floatables	1	-	None	None	None	None
Hardness	2	mg/l	250	250	500	500
Dissolved Oxygen	1	mg/l	8	7	7	5 (28C)
Odour	2	-*	NOO	NOO	NOO	NOO
Oxidisability		mg/l	5	7	7	8
pH	1	-	6.5 - 8.5	6.5 - 8.5	6.5 - 9.0	6.5 - 9.0
Salinity		ppt	1	1	1	1
Taste	2	-**	NOT	NOT	NOT	NOT
Temperature	2	°C	30 °C, Normal±	30 °C, Normal±	30 °C, Normal±	30 °C, Normal±
Total Dissolved Solids	2	mg/l	1000	1000	1000	1000
Total Suspended Solid	1	mg/l	50	50	100	100
Transparency (Secchi)	1	m	0.6	0.6	0.3	0.3
Turbidity	1	NTU	50	50	100	250
Total Dissolved Materials	2	mg/l	500	500	1000	1000
Biochemical Oxygen Demand (BOD)	1	mg/l	3	3	5	7
Chemical Oxygen Demand (COD)	1	mg/l	10	10	25	25
NUTRIENTS						
Ammoniacal Nitrogen	1	mg/l	0.3	0.3	0.5	0.5
Ammonia	1	mg/l	0.01	0.02	0.03	0.03
Chlorophyll-a	1	µg/l	0.7	7	20	70
Nitrate	1	mg/l	7	7	10	10
Nitrite	1	mg/l	0.04	0.04	0.04	0.04
Sulphate		mg/l	250	250	250	250
Total Phosphorus	1	mg/l	<0.005	<0.005	<0.005	<0.005
MICROBIAL CONSTITUENTS						
Clostridium perfringens (including spores)		count/L	Absent	Absent	Absent	Absent
Cryptosporidium sp	1	count/L	Absent	Absent	Absent	Absent
<i>E.coli</i>	2	cfu (colony forming units; cfu/100mL)	200 (126)	200	200	2000
Enterococci	1	cfu/100ml	(35)	-	-	-
Enteroviruses	1	PFU/l	-	-	-	-
Faecal Coliform	1	Counts/100ml	100	100	1000	1000
Giardia SP	1	cfu/100ml	Absent	Absent	Absent	Absent
Leptospira	1	cfu/100ml	Absent	Absent	Absent	Absent
Salmonella		Counts/ l	0	0	0	0
Total Coliform	1	Counts/100ml	5000	5000	10000	10000
ORGANICS/PESTICIDES						
Oil & Grease	1	mg/l	1.5	1.5	1.5	1.5
Oil & Grease (Emulsified Edible)	1	mg/l	7:N	7:N	7:N	7:N
Oil & Grease (Mineral)	1	mg/l	0.04:N	0.04:N	0.04:N	0.04:N
Total Pesticides	1	µg/l	None	None	0.001	0.001
Toxicants (heavy metal, organics)	1	µg/l	?			

