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Water quality assessment of recreational waterbodies in Jengka, Malaysia

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ABSTRACT. Recreational waterbodies support community activities and provide important ecosystem services. This study assessed physicochemical parameters and metal concentrations in two recreational waterbodies in Jengka, Pahang, Malaysia: Woodtech Lake and the Jengka Wonderland water-park pond. Fifteen water samples were collected from each site and analysed for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, iron (Fe), aluminium (Al), and manganese (Mn). Woodtech Lake had lower mean EC, TDS, and salinity values of 59 µS/cm, 116 mg/L, and 56 ppm, respectively, compared with 401.6 µS/cm, 806.8 mg/L, and 401.8 ppm at Jengka Wonderland. Metal concentrations were also lower at Woodtech Lake. Aluminium and Fe were detected at both sites, whereas Mn was detected only at Jengka Wonderland. Iron had the highest mean concentration among the measured metals, while the mean Al concentration at Jengka Wonderland (0.088 mg/L) exceeded the selected guideline value of 0.06 mg/L. The reported metal evaluation index (MEI) values indicated low metal contamination at both sites, with higher values at Jengka Wonderland. These differences may reflect variation in catchment conditions and surrounding land-use activities. The findings provide baseline information for monitoring and managing recreational waterbodies in Jengka. Further assessment, including microbiological analysis and seasonal monitoring, is required to establish their suitability for recreational use.

Keywords: Water quality, recreational lake, metal, in situ parameter

1. INTRODUCTION

Lakes are important freshwater ecosystems that serve a variety of ecological, social, and economic purposes, including water supply, fishing, recreation, tourism and biodiversity conservation. In Malaysia, recreational lakes have grown in importance as communal spaces that promote outdoor activities and improve public health. However, rapid urbanization, agricultural activities, recreational pressure and land-use changes with lake catchments may negatively impact water quality, posing a threat to ecosystem health and public safety (Sharip et al., 2014). Therefore, continuous monitoring and assessment of recreational lake water quality are needed for long-term management and conservation of aquatic resources.

Lake water quality degradation may be influenced by nutrient enrichment, silt accumulation and metal contamination. Excess fertilizer inputs can accelerate eutrophication, resulting in algal blooms, low dissolved oxygen, and ecological imbalances (Sharip et al., 2014; Kitan & Sinang, 2020). Heavy metals such as copper (Cu), and zinc (Zn) can accumulate in aquatic environments due to natural weathering and anthropogenic activities, posing potential risks to aquatic organisms and human health (Malsiu et al., 2020; Das et al., 2024; Dippong & Resz, 2024).

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Physicochemical parameters, water quality indices, trophic status indicators, and metal evaluations have been used in various studies to assess lake water quality in Malaysia. For instance, Prasanna et al. (2012) assessed a lake in Miri to elucidate the heavy metal contamination, Kamarudzaman et al. (2014) studied the water quality of Timah Tasoh Lake in Perlis, while Che Mood (2018) evaluated water quality of Varsity Lake at University of Malaya. Similarly, Kitan and Sinang (2020) assessed eutrophication indicators in Slim River Lake, emphasizing the need for nutrient monitoring in recreational waters. Several others have shown that integrating water quality assessment with contamination and health risk assessment can support lake management policies (Malsiu et al., 2020; Das et al., 2024; Tanjung et al., 2024).

Jengka, located in Pahang, Malaysia, is a fast-developing area with extensive agricultural, residential, educational and recreational services over the past twenty years (Sulaiman et al., 2023). This suburban area experiences an annual precipitation of roughly 2000 mm and maintains a daily average temperature ranging from 24 to 35 ºC. Increases in land-use activities near lake waterbodies may increase pollutant inputs via surface runoff, sediment transport, and anthropogenic disturbances. Despite the increasing importance of recreational water resources in this area, water quality data for Jengka's recreational lakes remain limited. Previous research in Jengka focused on metal contamination in recreational rivers caused by human and natural processes (Sulaiman et al., 2022). Insufficient baseline lake water quality data may impede good environmental management, pollution control and long-term recreational use. Thus, this preliminary study of lake water quality in Jengka will verify its current state, identify environmental pressures, and provide scientific evidence for future management and conservation efforts.

2. METHODOLOGY

2.1. Materials and Chemicals

This study was carried out at two different types of recreational water bodies in Jengka, Pahang. The first study site was Woodtech Lake at UiTM Cawangan Pahang (Figure 1a). The lake is surrounded by vegetation, with minimal man-made structures. This lake was chosen because it is frequently utilised by students for outdoor activities and educational purposes. The second location is Jengka Wonderland, a water park located outside of the UiTM campus (Figure 1b). The water park is enclosed by an extensive built-up area and agricultural land. The public frequently uses this park for recreational purposes. Since the pond ecosystem differs from a lake, it provides a suitable comparison for examining differences in water quality and possible contamination sources.

The samples were collected from both locations in October 2025. Five sampling points were selected at each site, with three replicate samples collected at each point. The samples were collected at a depth of 15 cm below the water surface using a grab sampling technique with each container properly cleaned. A multi-function water quality meter was used to determine temperature (°C), pH levels, salinity, total dissolved solids (TDS), and electrical conductivity (EC) (in situ measurement). To ensure reliable findings, the sensor was calibrated and rinsed with distilled water before and after measurement.

a b

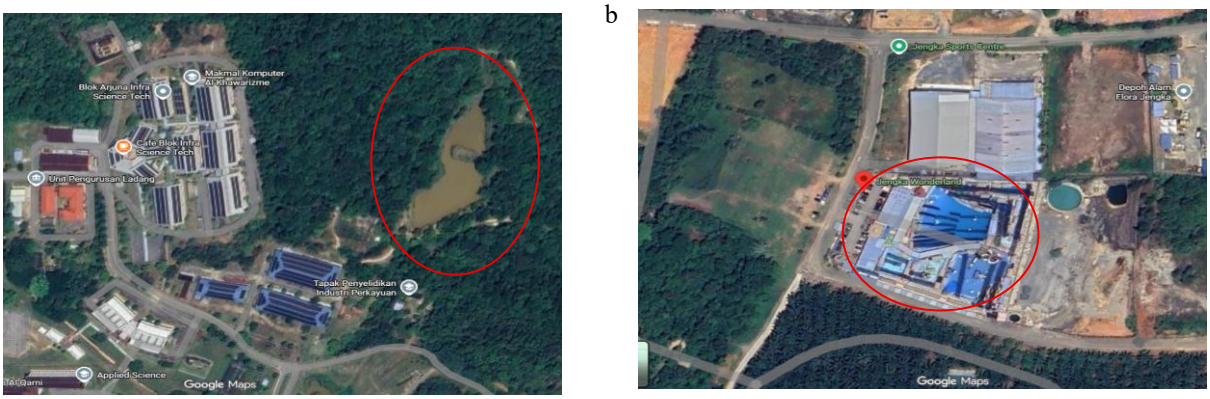

Figure 1. Sampling locations, indicated by red circles: (a) Woodtech Lake at UiTM Cawangan Pahang and (b) the Jengka Wonderland water-park pond.

Samples were also analysed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) to determine potential metal concentrations. Each water sample was acidified to pH2 and stored at 4 ºC prior to ICP-OES analysis. Samples were filtered using a syringe filter with a pore size of 0.45 µm to remove suspended particles that may cause blockages in the ICP-OES system. To confirm the analytical accuracy, reagent blanks, duplicate samples, and standard samples were prepared. The measured recovery rates were between 85-120%.

Data obtained from in situ measurement and ICP-OES analysis were summarised using descriptive statistics. The in situ data were compared to guideline values for recreational use (MOH, 2017). The metal concentration data were analysed via metal evaluation index (MEI) that concerned single metal content and was computed using Equation 1 (Edet and Offiong, 2002):

$$MEI = Mc/Mmac \quad (1)$$

Mc signifies the metal's concentration, whereas Mmac represents the metal's maximum allowable concentration. To assess the MEI, this study used two allowable metal concentrations: the Malaysian National Water Quality Standard (NWQS) and the World Health Organization (WHO). MEI can be characterised as low pollution (<10), moderate pollution (10-20), or high pollution (>20).

3. RESULTS AND DISCUSSION

3.1. In-situ water quality

The in-situ water quality data showed distinct differences between Woodtech Lake and Jengka Wonderland, demonstrating the impact of local environmental variables and nearby land-use activities on water characteristics. Woodtech Lake had a higher mean temperature (34.1°C) than Jengka Wonderland (32.28°C) as seen in Table 1. The temperatures in both waterbodies were near or over the approved range of 21.2-32.2°C (MOH, 2017). The increased temperatures may be attributed to Malaysia's tropical climate, intense radiation, and insufficient shading near the sampling sites. Similar findings have been observed in other Malaysian waterbodies, where surface water temperatures reach 30 ºC due to hot weather (Sharip et al., 2014; Juen et al., 2022). Woodtech Lake's comparatively

higher temperature could imply a lower water level or more direct sunshine. Elevated water temperatures can speed up microbial activity and nitrogen cycling, potentially impacting eutrophication processes in freshwater environments.

The pH levels measured in both waterbodies indicate roughly neutral conditions. Woodtech Lake had a mean pH of 6.77, whereas Jengka Wonderland had a slightly higher average pH of 7.14. Jengka Wonderland's pH is within the recommended range of 7.0-7.8 (MOH, 2017), although Woodtech Lake's pH was somewhat lower. Woodtech Lake's slightly acidic condition could be the consequence of organic matter decomposition, surface runoff or natural humic compounds entering the lake. Similar findings have been reported in tropical freshwater lakes where organic matter decomposition causes lower pH levels (Kamarudzaman et al., 2014). The steady pH values, as seen by low coefficients of variation (3.84-5.09%) indicate consistent buffering capability and limited short-term variations in both waterbodies.

There were substantial differences in TDS, EC and salinity between the two waterbodies. Woodtech Lake had lower mean TDS (116 mg/L), EC (59 µS/cm), and salinity (56 ppm) than Jengka Wonderland, which had mean values of 806.8 mg/L, 401.6 µS/cm, and 401.8 ppm, respectively. The higher values obtained at Jengka Wonderland suggest a larger concentration of dissolved minerals and ionic compounds in the water column. Surface runoff from nearby built areas, recreational facilities, roadways or agricultural land may supply the lake with more dissolved salts, fertilisers and other inorganic compounds. Jengka is surrounded by agricultural areas and earlier research in the area has indicated anthropogenic activities as potential drivers of water quality deterioration (Sulaiman et al., 2022). Fertiliser use, soil erosion, and stormwater runoff can increase dissolved solid mobilization into recipient waterbodies. Relationship between land-use activities and higher conductivity and TDS have been seen in freshwater lakes around the world (Prasanna et al., 2012; Tanjung et al., 2024).

TDS concentration in Jengka Wonderland (806.8 mg/L) remained lower than the recommended limit of 1000 mg/L (MOH, 2017), suggesting that the water is suitable for recreational use. However, the highest recorded TDS value (1105 mg/L) exceeded the threshold, indicating periodic increases in dissolved solids that may require additional investigation. High levels could be due to rainstorms, seasonal runoff, or local pollutant sources. In contrast, Woodtech Lake has very low TDS values, representing poor mineralisation and negligible anthropogenic effects.

The coefficient of variation (CV) demonstrates further gaps in water quality stability between the two waterbodies. Woodtech Lake has low variability in all measured parameters (CV<7%), indicating very stable water conditions across the sampling sites. Nevertheless, Jengka Wonderland exhibited significant diversity in TDS, EC and salinity (about 36%), suggesting spatial heterogeneity and potential dissolved substance inputs at specific places. High variability could mean variable hydrological conditions, uneven pollution distribution, or multiple inflow sources influencing lake water quality.

Table 1. In-situ water quality parameters of Woodtech Lake and Jengka Wonderland (*n*=15).

Location/ statistics	Temperature (℃)	pH	Salinity (ppm)	Total Dissolved Solids (TDS) (mg/L)	Electrical Conductivity (EC) (µS/cm)
Woodtech Lake					
Min	33.6	6.49	54	110	56
Max	34.8	7.05	58	124	66
Mean	34.1	6.77	56	116	59
SD	0.43	0.26	1.58	5.47	4
CV (%)	1.27	3.84	2.82	4.72	6.77
Jengka Wonderland					
Min	31.3	6.67	217	438	217
Max	34.2	7.58	548	1105	548
Mean	32.28	7.14	401.8	806.8	401.6
SD	1.12	0.36	143.49	288.08	143.54
CV (%)	3.44	5.09	35.71	35.70	35.74
MOH (2017)	21.2-32.2	7.0-7.8	-	<1000	-

3.2. Metal Concentrations

Table 2 displays metal concentrations for Woodtech Lake and Jengka Wonderland. The ICP-OES analysis detected three metals (Al, Fe, and Mn); however, several other metal elements were discovered to be below the detection limit (Cd, Cu, Pb, and Zn) and hence were not reported. The varying concentrations of aluminium (Al), iron (Fe), and manganese (Mn) indicate differences in environmental conditions and possibly anthropogenic influences between the two recreational waterbodies.

Woodtech Lake had 0.02-0.05 mg/L aluminium (Al) values, with a mean of 0.036 mg/L. However, Jengka Wonderland had greater concentrations, ranging from 0.03 to 0.28 mg/L with a mean of 0.088. The mean Al concentration in Woodtech Lake was below the NWQS standard of 0.06 mg/L, implies minimum contamination risk. Jengka Wonderland's mean Al concentration slightly exceeds the permissible limit, showing land-use enrichment. Features within the Jengka Wonderland, including aluminum-containing metallic components, corrosion of infrastructure, and aluminum-based coagulants (e.g., alum) used in water treatment, can contribute trace amounts of aluminum to the aquatic environment (USEPA, 2018). Perhaps surface runoff transporting suspended soil particles may increase Al concentration in Jengka Wonderland. In tropical ecosystems, watershed disturbances increase Al-bearing sediment movement (Prasanna et al., 2012).

Iron (Fe) dominated both waterbodies. Jengka Wonderland had fourteen times more Fe (0.70 mg/L) than Woodtech Lake (0.05 mg/L), however, all samples were below the NWQS limitation of 1.0 mg/L. Higher Fe concentration in Jengka Wonderland may be due to catchment-related anthropogenic inputs. Lakes with agricultural runoff and exposed soil have higher dissolved and particulate Fe concentration (Dippong & Resz, 2024). Although the concentrations were below the recommended values, increasing Fe concentration can elevate turbidity, specifically during low dissolved oxygen when Fe becomes more soluble.

Manganese (Mn) concentrations ranged from 0.01 to 0.03 mg/L with a mean of 0.02 in Jengka Wonderland. However, Mn concentrations were below the detection limit for Woodtech Lake. The value was much lower than the NWQS (0.1 mg/L) and WHO (0.08 mg/L) guidelines, posing no harm to recreational users and aquatic

organisms. Under reduced conditions, Mn can be released into water during natural weathering. Low amounts reflect minimal Mn mobilisation in the lake system and limited anthropogenic contribution.

Jengka Wonderland consistently had higher metal concentration than Woodtech Lake. This trend matches higher TDS, EC and salinity measurements, signifying more catchment-derived dissolved and particulate inputs. The lake's elevated metal levels may be due to agricultural runoff, recreation, soil erosion, and stormwater drainage. Sulaiman et al. (2022) linked anthropogenic activities to increased metal concentrations in surface water. Woodtech Lake had a high coefficient of variation (CV) for Al (37.26%) but low CV for Fe (15.60%), suggesting that Al concentrations changed more widely than Fe. Manganese and iron revealed substantial variability (35.35% and 33.04%, respectively) in Jengka Wonderland, showing heterogeneous distribution patterns and local metal input sources. Sediment deposition, inflow sites, hydrological conditions, and land-use activities may cause such variations.

Table 2. Metal concentrations (mg/L) of Woodtech Lake and Jengka Wonderland (*n*=15).

Location/ statistics	Al	Fe	Mn
Woodtech Lake			
Min	0.02	0.01	BDL
Max	0.05	0.19	BDL
Mean	0.036	0.05	BDL
SD	0.01	0.007	BDL
CV (%)	37.26	15.6	BDL
Jengka Wonderland			
Min	0.03	0.34	0.01
Max	0.28	0.93	0.03
Mean	0.088	0.7	0.02
SD	0.01	0.23	0.007
CV (%)	12.15	33.04	35.35
NWQS (2024)	0.06	1	0.1
WHO (2026)	-	-	0.08

BDL below detection limit

3.3. Metal evaluation index (MEI)

Table 3 shows the MEI values for Al, Fe, and Mn in Woodtech Lake and Jengka Wonderland. In general, the MEI values show low metal pollution level. Higher MEI values reflect metal increment and greater environmental risk. There are clear differences between the two recreational waterbodies. Jengka Wonderland had higher MEI values than Woodtech Lake. Perhaps this situation may be due to more metal inputs from anthropogenic activities. In Jengka Wonderland, Al had the highest MEI (1.46), followed by Fe (0.70) and Mn (0.20). MEI values were lower at Woodtech Lake with Al (0.60), Fe (0.05) and no value for Mn.

The MEI value for Al in Jengka Wonderland suggests Al is the main potential metal polluting the waterbody. Higher MEI value reflects enrichment inputs from runoff, soil erosion and suspended particles. Aluminium, one of the most abundant elements in tropical soils, is mobilized into surface waters by intense rainfall, land disturbance and agriculture. As Jengka was dominated by agricultural activities, sediment transport during runoff events may

increase sediment transport and consequently increase Al concentrations. Similar findings revealed that tropical freshwater lake receive Al from catchment disturbances and erosion (Prasanna et al., 2012; Malsiu et al., 2020).

Although Fe concentrations were low, Jengka Wonderland had higher MEI than Woodtech Lake, indicating geochemical and anthropogenic impacts. Tropical lateritic soils are rich in Fe, which can enter aquatic ecosystems through weathering, sediment resuspension and surface runoff. Jengka Wonderland MEI for Fe matches the high EC, TDS and salinity values, which indicates more dissolved and particulate debris. Jengka Wonderland has a low MEI (0.20) for Mn, indicating a lower index value than those for Al and Fe.

Table 3. Metal evaluation index values for Woodtech Lake and Jengka Wonderland.

Location	Standard	Al	Fe	Mn
Woodtech Lake	NWQS 2024	0.60	0.05	-
	WHO 2026	-	-	-
Jengka Wonderland	NWQS 2024	1.46	0.70	0.20
	WHO 2026	-	-	0.25

4. CONCLUSION

Woodtech Lake had lower TDS, EC, salinity and metal concentrations than Jengka Wonderland, indicating differences in water quality between the two sites. The higher concentrations at Jengka Wonderland may reflect inputs associated with surrounding land-use activities, although their sources require further investigation. Most measured parameters were within the selected guideline values; however, the mean Al concentration at Jengka Wonderland exceeded the selected threshold, identifying Al as a priority for further monitoring. These findings provide baseline data for managing recreational waterbodies in Jengka. Regular monitoring across seasons, incorporating dissolved oxygen, nutrients, microbiological indicators, additional metals such as Cd, Pb and Zn, and emerging pollutants such as microplastics, is recommended to assess ecological conditions and establish recreational suitability.

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AUTHOR CONTRIBUTIONS

Fazrul Razman Sulaiman conceptualised and supervised the study, performed the formal analysis, and wrote the original draft. Sabarina Md Yunus reviewed and edited the manuscript. Both authors approved the final version of the manuscript.

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DECLARATION OF GENERATIVE AI IN THE WRITING PROCESS

ChatGPT and QuillBot were used to improve language clarity and writing quality. The authors reviewed the revised text and take responsibility for the final manuscript.

DATA AVAILABILITY

The data are available from the corresponding author upon reasonable request.

COMPETING INTERESTS

The authors declare that there are no competing interests.

COMPLIANCE OF ETHICAL STANDARDS

Not applicable.

SUPPLEMENTARY MATERIAL

Not applicable.

REFERENCES

Che Mood, N. (2018), *Surface water quality assessment for sustainable water management in Varsity Lake, University Malaya*. Master's thesis, University of Malaya. https://knova.um.edu.my/student_works_2010s/5442

Das, B., Islam, M. A., Tamim, U., Ahmed, F. T. & Hossen, M. B. (2024), Heavy metal analysis of water and sediments of the Kaptai Lake in Bangladesh: Contamination and concomitant health risk assessment. *Applied Radiation and Isotopes*, 210, 111358. https://doi.org/10.1016/j.apradiso.2024.111358

Dippong, T. & Resz, M.-A. (2024), Heavy metal contamination assessment and potential human health risk of water quality of lakes situated in the protected area of Tisa, Romania. *Heliyon*, 10(7), e28860. https://doi.org/10.1016/j.heliyon.2024.e28860

Edet, A. E. & Offiong, O. E. (2002), Evaluation of water quality pollution indices for heavy metal contamination monitoring. A study case from Akpabuyo-Odukpani area, Lower Cross River Basin (southeastern Nigeria). *GeoJournal*, 57(4), 295–304. https://doi.org/10.1023/B:GEJO.0000007250.92458.de

Juen, J. W. Y., Vitales, J. W., Audrey, N., Ladah, S. & Ikhwan, M. K. (2022), Swimming pool water quality: A case study for chlorine alternative swimming pool. *Jurnal Kejuruteraan, Teknologi dan Sains Sosial*, 8(1, Special Issue ICRISC2022), 294–302.

Kamarudzaman, A. N., Feng, V. K., Ab Jalil, M. F. & Abdul Aziz, R. (2014), Water quality study of Timah Tasoh Lake in Perlis, Malaysia. *Advanced Materials Research*, 925, 669–673.

Kitan, Y. A. & Sinang, S. C. (2020), Evaluation of eutrophication indicators in Slim River Lake, Perak–Malaysia. *Research Review International Journal of Multidisciplinary*, 5(11), 1–6. https://doi.org/10.31305/rrijm.2020.v05.i11.001

Malsiu, A., Shehu, I., Stafilov, T. & Faiku, F. (2020), Assessment of heavy metal concentrations with fractionation method in sediments and waters of the Badovci Lake (Kosovo). *Journal of Environmental and Public Health*, 2020, 3098594. https://doi.org/10.1155/2020/3098594

MOH (Ministry of Health) (2017), *Garispanduan Pemantauan Kualiti Air Kolam Renang*. https://hq.moh.gov.my/engineering/images/perkhidmatan/kas/muat-turun/garis-panduan-kolam-renang_content.pdf

NWQS (National Water Quality Standard Malaysia) (2024), *Standard Kualiti Air Kebangsaan*. https://www.doe.gov.my/standard-dan-indeks-kualiti/standard-kualiti-air-kebangsaan-5/

Prasanna, M. V., Praveena, S. M., Chidambaram, S., Nagarajan, R. & Elayaraja, A. (2012), Evaluation of water quality pollution indices for heavy metal contamination monitoring: A case study from Curtin Lake, Miri City, East Malaysia. *Environmental Earth Sciences*, 67(7), 1987–2001. https://doi.org/10.1007/s12665-012-1639-6

Sharip, Z., Zaki, A. T. A., Shapai, M. A. H. M., Suratman, S. & Shaaban, A. J. (2014), Lakes of Malaysia: Water quality, eutrophication and management. *Lakes & Reservoirs*, 19, 130–141. https://doi.org/10.1111/lre.12059

Sulaiman, F. R., Jusoh, M. S. A., Nasaruddin, A. A. & Sulaiman, N. (2023), Assessment of tropical suburban surface soils contamination from Jengka, Malaysia. *Environmental Quality Management*, 33(1), 71–78. https://doi.org/10.1002/tqem.22024

Sulaiman, F. R., Shamshudin, C. M. F. H. C. M., Abd Rahim, M. H. & Sulaiman, N. (2022), Assessment of metal concentrations from recreational rivers in a tropical region (Jengka, Malaysia). *Applied Water Science*, 12(6), 127. https://doi.org/10.1007/s13201-022-01643-1

Tanjung, R. H. R., Indrayani, E., Agamawan, L. P. I. & Hamuna, B. (2024), Water quality assessment to determine the trophic state and suitability of Lake Sentani (Indonesia) for various utilisation purposes. *Water Cycle*, 5, 99–108. https://doi.org/10.1016/j.watcyc.2024.02.006

USEPA (U.S. Environmental Protection Agency) (2018), *Final aquatic life ambient water quality criteria for aluminum in freshwater*. https://www.epa.gov/wqc/2018-final-aquatic-life-criteria-aluminum-freshwater

WHO (World Health Organization) (2026), *Guidelines for drinking-water quality*. 4th ed. https://cdn.who.int/media/docs/default-source/wash-documents/water-safety-and-quality/dwq-guidelines-4/gdwq_4ed_with_third-addenda_chemical-fact-sheets.pdf?sfvrsn=77d972e1_5

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