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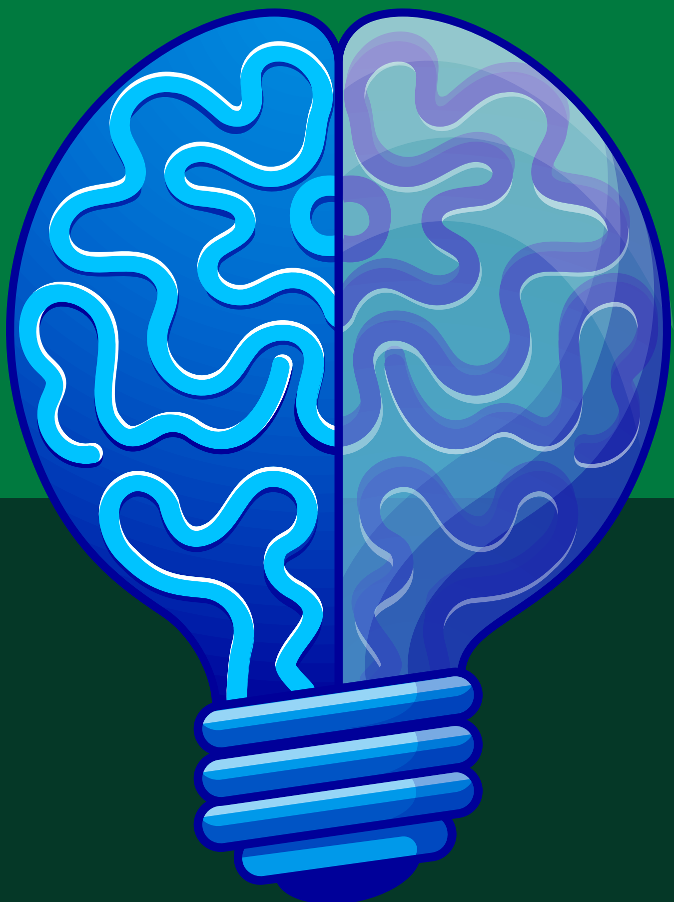

BIOLOGY ~ CHEMISTRY ~ PHYSICS

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Preface

The Scientific Project Colloquium offers a platform for publishing Diploma Science final year projects (FYP). The objective is to effectively distribute research findings throughout all scientific disciplines. The primary objective of including final year projects into the course curriculum is to encourage students to put their theoretical knowledge into practical applications.

We would like to express our gratitude to our primary establishment, the Faculty of Applied Sciences and Universiti Teknologi MARA, Perak Branch, for their invaluable assistance.

Lastly, we would like to express our gratitude to all of the authors for the tremendous help in preparing the articles, without which this undertaking would not have been completed.

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QUANTITATIVE ASSESSMENT OF HEAVY METAL CONTAMINATION IN LAKE WATER USING ATOMIC ABSORPTION SPECTROMETRY

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Abstract: This study investigated the concentrations of cadmium (Cd), chromium (Cr), and nickel (Ni) in two freshwater lakes and evaluated their compliance with the Malaysian National Water Quality Standards (NWQS). The analytical procedure was validated using calibration curves with good linearity (R^2 = 0.984–0.9949). The results revealed severe heavy metal contamination, with all metals exceeding permissible limits. Cadmium concentrations (0.34–0.40 ppm) and nickel concentrations (1.52–1.53 ppm) showed the most dramatic exceedances, surpassing their regulatory thresholds (0.01 ppm and 0.05 ppm, respectively) by more than an order of magnitude. Chromium levels (0.1–0.3 ppm) also consistently breached the safety limit (0.05 ppm), with concentrations 2 to 6 times higher than allowed. The findings confirm a critical level of pollution, with the notably high concentrations of Cd and Ni being of particular concern due to their chronic toxicity and bioaccumulation potential, indicating a substantial risk to aquatic ecosystem integrity and public health.

Keywords: *Heavy metal, Water pollution, Lake water, Bioaccumulation*

INTRODUCTION

Freshwater ecosystems are vital for sustaining global biodiversity, human health, and socioeconomic development. However, these critical resources face increasing threats from anthropogenic activities, including rapid urbanization, industrial discharge, and agricultural runoff, leading to widespread contamination by heavy metals (Islam et al., 2015). Among these pollutants, cadmium (Cd), chromium (Cr), and nickel (Ni) are particularly concerning due to their environmental persistence, toxicity, and capacity to bioaccumulate in aquatic food webs (Ali et al., 2019). The introduction of these metals into freshwater systems poses significant long-term risks to ecological integrity and public health.

In Malaysia, the protection of water resources is guided by the National Water Quality Standards (NWQS), which set permissible limits for pollutants in drinking and raw water. Nevertheless, consistent findings of heavy metal contamination in rivers, lakes, and reservoirs highlight ongoing challenges in pollution control, often linked to industrial effluents, untreated wastewater, and land-use changes (Al-Badaii et al., 2022; Yap et al., 2021). Exposure to elevated levels of Cd, Cr, and Ni is associated with serious health outcomes, including nephrotoxicity, carcinogenesis, and neurotoxic effects, underscoring the need for stringent monitoring (Genchi et al., 2020).

"Recent studies in Malaysia continue to document heavy-metal contamination in inland water bodies. For instance, Ahmed et al. (2020) reported persistent cadmium and chromium along the Langat River supply chain, even after water treatment. In Sabah, Rahim et al. (2024) found elevated levels of chromium and nickel in both water and sediment of the Lohan River. Bioindicator research also supports these concerns; Jumaat & Ab Hamid (2023) demonstrated bioaccumulation of cadmium in damselfly larvae from Malaysian rivers. Moreover, studies of wastewater effluents reveal that nickel and cadmium remain prevalent in treated sewage plant discharges, indicating potential sources of freshwater contamination.

Advances in analytical techniques such as inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma optical emission spectroscopy (ICP-OES) have significantly enhanced the detection of trace metals, offering high sensitivity and multi-element capability (Beauchemin, 2022). However, in many environmental laboratories, particularly in developing regions, flame atomic absorption spectroscopy (FAAS) remains the method of choice due to its affordability, operational simplicity, and instrument availability, despite its lower sensitivity compared to more advanced techniques. When properly calibrated, FAAS continues to provide reliable and accurate quantification for routine monitoring of heavy metals in water samples.

This study aims to determine the concentrations of cadmium, chromium, and nickel in two selected lakes using FAAS and evaluate their compliance with the Malaysian NWQS. By quantifying the extent of heavy metal pollution and assessing its regulatory implications, this research provides essential baseline data to inform management strategies, support regulatory enforcement, and protect both aquatic ecosystems and public health.

METHODOLOGY

Chemicals and instrumentation

All reagents and solvents used were of analytical grade or HPLC grade. Nitric acid (HNO_3) was purchased from Fisher Scientific. Standard solutions of chromium, nickel and cadmium were purchased from Merck KGaA, Darmstadt, Germany. Deionized water was used for analysis. Perkin Elmer Atomic Absorption Spectrometer AAnalyst 700 equipped with a deuterium background corrector and WinLab32 software was used for analysis.

Preparation of stock solutions

Stock solutions of chromium (Cr), cadmium (Cd), and nickel (Ni) were prepared at a concentration of 1000 ppm in 250 mL volumetric flasks using deionized water. Working standard solutions (0.2–5 ppm) were subsequently prepared by serial dilution of the respective stock solutions.

Sampling and pre-treatment of samples

Water sampling was conducted at three locations within Lake Alpha and Lake Zeta near UiTM Tapah Campus, Perak, Malaysia. At each site, samples were gathered from a depth of 10–15 cm below the surface using pre-cleaned, acid-washed 500 mL high-density polyethylene (HDPE) bottles. To remove suspended particulates, the samples were filtered through 0.45 µm Millipore filters. All samples were then transported on ice and refrigerated at 4°C until laboratory analysis.

Water samples preparation

A 100 mL aliquot of an acid-preserved water sample was subjected to acid digestion. The sample was transferred to a 250 mL Erlenmeyer flask, mixed with 5 mL of concentrated HNO_3, and covered with a watch glass. The mixture was heated slowly on a hot plate with the aid of boiling chips and evaporated until the volume was reduced to 15–20 mL. Subsequently, 10 mL of concentrated HNO_3 was added to complete the digestion. After cooling, the digestate was diluted with 50 mL of deionized water and re-heated to boiling to expel nitrogen oxides. Finally, the sample was filtered, made up to a final volume of 100 mL with deionized water, and mixed thoroughly.

Method validation

The concentrations of heavy metals were determined using an external calibration method. A series of calibration standards were prepared from a 100-ppm stock solution. The calibration ranges were 1–5 ppm for Cr, 0.2–1.0 ppm for Cd, and 0.5–4.0 ppm for Ni. Linearity of the analytical response was established by performing a linear regression analysis of the peak area versus concentration for each metal.

FINDINGS

The calibration curves for all metals exhibited good linearity, with correlation coefficients (R^2) ranging from 0.984 to 0.9949 (Figure 1).

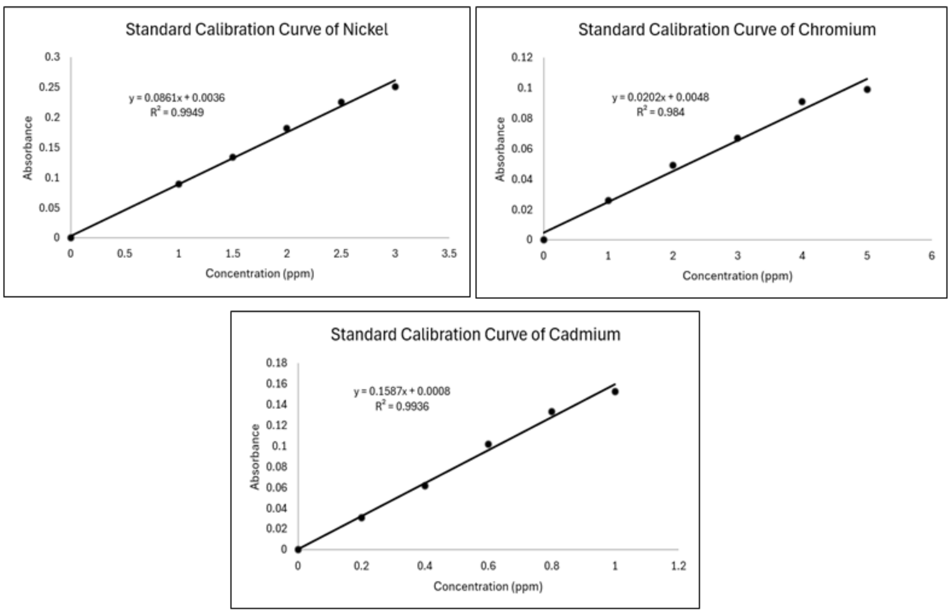

Figure 1 Standard calibration curve for Cd, Cr and Ni

Heavy Metal Concentrations
The concentrations of heavy metals in Lakes Alpha and Zeta are presented in Figure 2, respectively. In both lakes, nickel was the most prevalent metal, with concentrations ranging from 1.52 to 1.53 ppm. This was followed by cadmium (0.34–0.40 ppm), while chromium exhibited the lowest concentrations (0.1–0.3 ppm). The consistent trend across all sampling points highlights nickel as the dominant contaminant in these ecosystems.

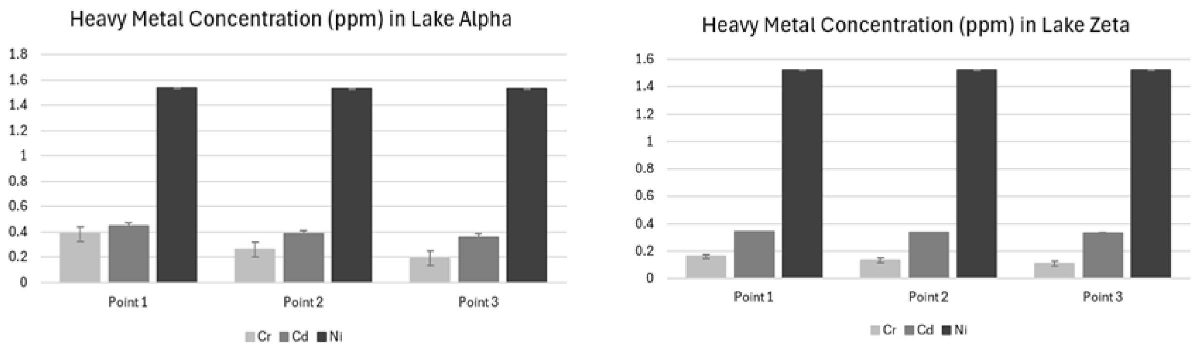

Figure 2 Heavy metals concentration in both lakes

The measured concentrations of heavy metals were compared against the National Water Quality Standards for Malaysia (NWQS) by the Department of Environment Malaysia (DOE). The maximum permissible levels (MPL) of Cr, Cd and Ni in drinking water (or raw water criteria) is presented in Table 1.

Table 1 National Water Quality Standards for Malaysia (NWQS) in drinking water (or raw water criteria)

Metal	Maximum permissible levels (ppm)
Cadmium	0.01
Chromium	0.05
Nickel	0.05

The analysis revealed severe heavy metal contamination in both lakes, with all measured metals exceeding national safety standards. The most dramatic exceedances were for cadmium (0.34–0.40 ppm) and nickel (1.52–1.53 ppm), which surpassed their permissible limits (0.01 and 0.05 ppm, respectively) by more than an order of magnitude. Chromium levels (0.1–0.3 ppm) also consistently breached the regulatory threshold (0.05 ppm), with concentrations 2 to 6 times higher than allowed. The elevated levels of Cd and Ni are of particular concern due to their well-documented chronic toxicity and potential for bioaccumulation in the food chain.

CONCLUSIONS
In conclusion, this study confirms severe heavy-metal contamination in the studied lakes, with levels of Cd, Ni, and Cr exceeding regulatory limits. The extreme exceedance of Cd and Ni is of particular concern due to their well-documented chronic toxicity and bioaccumulation potential. These findings underscore the urgent need for implementing effective pollution-control measures, continuous monitoring, and remediation strategies.

To mitigate these risks, future work should focus on identifying the specific pollution sources, evaluating bioaccumulation in the aquatic food web, and modeling long-term ecological risks. Strengthening regulatory enforcement and improving wastewater management are essential steps to safeguard both aquatic ecosystems and public health. This study provides critical baseline data that emphasizes the necessity of protecting freshwater resources from persistent toxic contaminants.

COMPLIANCE OF ETHICAL STANDARDS
Not applicable.

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Sekian, terima kasih.

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Saya yang menjalankan amanah,

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