Welcome to the Newsletter e-Science Putra. This issue presents the research activities from January to April 2026 which highlight the latest research findings by the selected faculty members.

HIGHLIGHTS
- Nanozyme-Engineered Silicon Quantum Dots for Glucose Detection
- Microplastics And Detection Techniques in Tioman, Mersing, Bali, Aceh and Sweden
- Halal@STEM: An Eye-Opening Journey Linking Syariah and Science
- Enhancing Rainfall Trend Detection under Autocorrelation and Nonlinearity
- AI-Driven Visualization for Statistical Learningh
- Zinc and Copper in Water Spinach Ipomoea aquatica from Peninsular Malaysia

NANOZYME-ENGINEERED SILICON QUANTUM DOTS FOR GLUCOSE DETECTION

Assoc. Prof. Dr. Jaafar Abdullah
Department of Chemistry, Faculty of Science, Universiti Putra Malaysia
Expertise: Analytical Chemistry, Biosensor & Chemical Sensor
Email: jafar@upm.edu.my

Nanozyme is a nanomaterial that exhibits enzyme-like catalytic activity. Nanozymes are engineered nanoparticles that can mimic the function of natural enzymes, such as oxidases, peroxidases, and catalases [1]. These synthetic materials are designed to perform specific biochemical reactions, similar to natural enzymes, but they often offer advantages like greater stability, lower cost, and tuneable catalytic properties [2]. Silicon quantum dots (SiQDs) are nanoscale silicon particles, typically with diameters of less than 10 nm [3], exhibiting size-dependent photoluminescence, high biocompatibility, and low toxicity. Their tunable optical and electronic properties, large surface area, and versatile surface functionalization make them attractive for sensing, bioimaging, optoelectronics, and catalytic (nanozyme-like) applications.

In this study, the synthesis of SiQDs using 3-aminopropyltriethoxysilane (APTES) as a silicon source, trisodium citrate as a reducing agent, and ethylene diamine as a capping agent through a hydrothermal process has been explored. The resulting SiQDs exhibit notable luminescent properties and water solubility. Furthermore, the quantum dots enable the highly sensitive and selective detection of glucose. The SiQDs were used as an indicator to reveal the fluorescence response of the system resulting from interactions with glucose that induced the self-aggregation and thus quenched the fluorescence intensity as shown in Fig. 1. The suggested fluorescent approach was effectively utilized for the detection of glucose, yielding satisfactory outcomes.

The effect of the SiQDs system in phosphate buffer solution at pH 7.2 towards various glucose concentrations was investigated in this study. Fig. 2 illustrates the dynamic response of the SiQDs system when standard glucose concentrations ranging from 0.1 to 1.0 mg/ml were introduced. As the glucose concentration increased, there was a gradual reduction in the fluorescence intensity of the SiQDs due to their quenching effect. A linear relationship was observed within the glucose concentration range of 0.1 to 0.8 mg/ml (with a slope of $y = 20249x - 1682.4$, $R^2 = 0.9804$), the detection limit (LOD) was calculated to be 0.03 mg/ml, which is slightly higher than that reported by Du et al. [4] (LOD = 0.002 mg/mL).
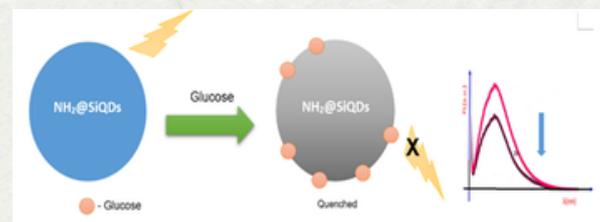

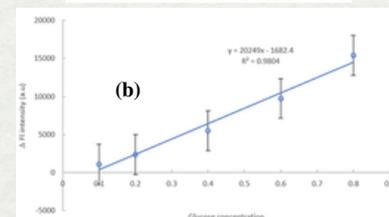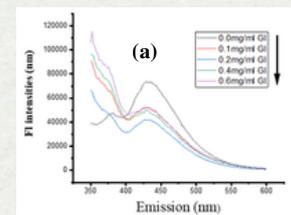Fig. 1: Schematic illustration of the $NH_2@SiQDs$ for sensitive detection of glucose

Fig. 2: a) Fluorescence emission response of SiQDs in a phosphate buffer solution containing different concentrations of glucose, b) Calibration curve of glucose concentration in the range of 0.1 to 0.8 mg/ml in PBS pH 7.2 consisting of SiQDs (0.5 mg/ml)

The synthesised nanozyme fluorescence sensor based on SiQDs demonstrates remarkable efficiency in detecting glucose, aligning with and even surpassing the performance of some previously reported sensors. In comparison to conventional enzymatic sensors, which suffer from stability issues due to enzyme degradation, the SiQDs-based nanozyme sensor offers enhanced longevity, consistent accuracy, and superior photostability.

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[1] Guliy, O., Dykman, L. (2024). Nanozyme-based sensors for cancer diagnosis, Biosensors and Bioelectronics X, 19, 100512.
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MICROPLASTICS AND DETECTION TECHNIQUES IN TIOMAN, MERSING, BALI, ACEH AND SWEDEN

Dr. Mohd Rashidi Abdull Manap
Department of Chemistry, Faculty of Science,
Universiti Putra Malaysia
Expertise: Analytical Chemistry, FTIR and Raman Spectroscopy, Quantum Chemistry, New Psychoactive Substance, Aerosol Characterization
Email: rashidichemistry@upm.edu.my

Research on microplastics (MPs) in several local and international locations such as Pulau Tioman and Mersing (Malaysia), Bali and Aceh (Indonesia), and Sweden has been carried out through international collaboration involving UPM and leading research laboratories from Asia, the United States and Europe. This cross-country study provides a consistent picture of the presence and diversity of small-sized plastic particles, generally defined as plastics with dimensions less than 5 mm (< 5 mm) as shown in Figure 1, in marine environments and coastal sediments. (Manap et al., 2025) In tropical areas such as Tioman, Mersing, Bali and Aceh, MPs have been found in different quantities. This international collaborative approach allows for direct comparisons between continents, thus strengthening the understanding that microplastic pollution is a global issue influenced by local factors and regional oceanographic processes.
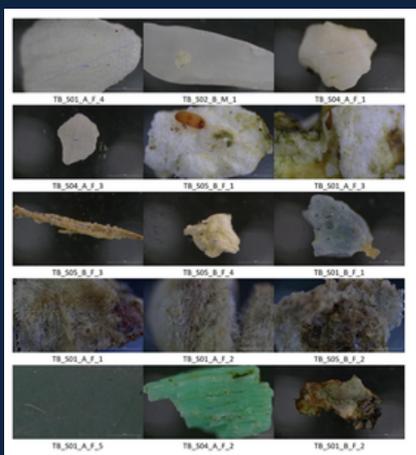

Figure 1: Various particles found during the microplastic sampling process.

In terms of detection and characterization techniques, this collaborative research used a nearly uniform and complementary analytical approach across all participating countries, in line with efforts towards standardization of microplastic study protocols. (Nakano et al., 2025) The initial process involved sampling coastal sediments or river water, followed by particle separation using density separation and size separation methods and visual observation for initial classification of size and morphology. As shown in Figure 2, polymer type identification was then performed using Attenuated total reflectance–Fourier transform infrared (ATR-FTIR) spectroscopy, supported by matching of polymer reference spectra and chemometric analysis such as Principal Component Analysis (PCA) to improve classification accuracy.

In Figure 3, other findings also highlight the value of integrating spectroscopic analysis with remote sensing hydrodynamics to elucidate the mechanism of microplastic deposition. (Manap et al., 2026). In selected studies in collaboration with international research partners, advanced vibrational techniques such as Raman microscopy and optical photothermal infrared spectroscopy (O-PTIR) were also used, especially for particles of very small size or with complex compositions. The combination of these techniques has enabled the identification of major polymer materials such as polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyester. Also, other materials are under-reported.
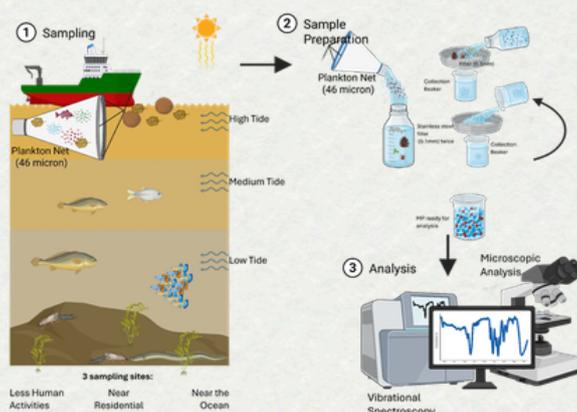

Figure 2: Workflow for detecting microplastics from rivers using density separation, microscopy and ATR-FTIR.
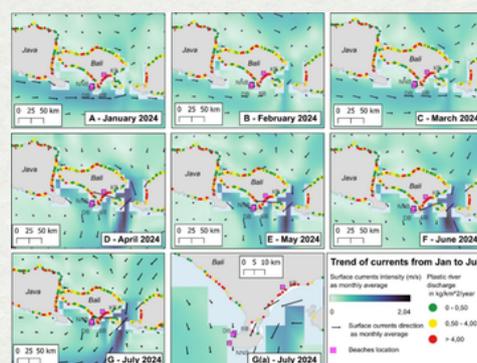

Figure 3: Surface current trends from January to July 2024 (A to G) and sources of impact (river discharge in kg/km²/year).

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HALAL@STEM: AN EYE-OPENING JOURNEY LINKING SYARIAH AND SCIENCE

Dr. Yazid Yaakob
Department of Physics,
Faculty of Science,
Universiti Putra Malaysia
Expertise: Material Science, Carbon Related Materials, Electron Microscopy
Email: yazidakob@upm.edu.my

Halal@STEM is more than an outreach programme—it is a bridge connecting syariah values, scientific literacy and future-ready skills for young Malaysians. Starting from knowledge transfer project in 2024, the initiative engaged urban community youth at PPR Intan Baiduri and secondary school students at SMK Pelagat, Terengganu, introducing Halal concepts through hands-on STEM experiments, digital content creation, guided reflection and career exposure. At PPR Intan Baiduri, participants explored Halal fundamentals, entrepreneurship and digital storytelling through multi-phased activities culminating in peer-led presentations that transformed learners from recipients of knowledge into community knowledge-sharers. Activities integrated Halal literacy, hands-on STEM modules, entrepreneurship awareness, digital communication and guided reflection, demonstrating how syariah and science intersect in real applications, including ingredient authentication, cleanliness assessment, product innovation and digital transparency across supply chains. Led by Dr. Yazid Yaakob, these engagements were made possible through collaboration between Universiti Putra Malaysia (UPM), Nestlé Malaysia, Halal Development Corporation (HDC), GIATMARA Kepong and local community, strengthening strategic joint organisation by UPM–IPPH and Nestlé Malaysia. The programme reflects a transdisciplinary approach involving the members of Halal Product Research Institute (IPPH), Faculty of Science (Prof. Madya Dr. Mohd Mustafa Awang Kechik and Dr. Muhammad Safwan Zaini), and Faculty of Computer Science and Information Technology (Dr. Shafinah Kamarudin), highlighting synergy between academia, industry and community.

At SMK Pelagat, students experienced Halal@STEM through four thematic STEM stations—Science, Technology, Engineering and Mathematics—where microscopes, imaging, sensors, structural challenges and data analytics illustrated how scientific testing, engineering design and digital tools uphold Halal authenticity [1] and safety. These learning experiences align with national aspirations to develop adaptive talent capable of applying science to societal needs, positioning Halal as a science-informed ecosystem driving technology and opportunity.

Programme outcomes across both sites demonstrated strong impact: evaluation scores at PPR Intan Baiduri increased from 76% to 92.2%, while overall satisfaction at SMK Pelagat reached 99%, with all STEM stations scoring above 90%. Beyond knowledge gains, students practised communication through videos, entrepreneurship-linked concepts and scientific demonstrations, aligning with Malaysia's strategic focus on science-driven Halal capability and high-technology adoption. Collectively, these outcomes show how integrating syariah and science nurtures ethical future leaders, supporting national priorities under the NSTIP 2021–2030 [2] and HIMP 2030 [3].

Figure 1: Microscope, Imaging and AI hands-on activities

Figure 2: Secretariat for Halal@STEM team from UPM, Nestle Malaysia and SMK Pelagat

References

1. Recent Advances in Halal Research Via Microscopy and Imaging Approaches: Opportunity and Challenges. Malaysian Journal of Microscopy. 2025, 21(1), pp. 320–337.
2. *National Science, Technology and Innovation Policy (NSTIP) 2021–2030. (priority: adaptive STI talent)*
3. H*alal Industry Master Plan 2030 (HIMP 2030). (priority: talent development, high-tech adoption & innovation)*

ENHANCING RAINFALL TREND DETECTION UNDER AUTOCORRELATION AND NONLINEARITY

Dr. Syafrina Abdul Halim
Department of Mathematics and Statistics,
Faculty of Science,
Universiti Putra Malaysia
Expertise: Extreme Value Theory, Time Series Analysis
Email: syafrina@upm.edu.my

Understanding long-term rainfall trends is essential for climate risk assessment, water resource management, and disaster preparedness. The Mann–Kendall (MK) trend test is widely used in hydroclimatic studies due to its nonparametric nature and robustness to non-normal data and outliers. However, its assumption of independence is frequently violated in rainfall time series, where autocorrelation and complex temporal structures are common, leading to inflated false trend detection. Several modified MK approaches have been proposed to address this issue, including Trend-Free Pre-Whitening (TFPW), which preserves deterministic trends while reducing autocorrelation, the Seasonal Mann–Kendall test (SMK), which accounts for seasonality and weak dependence, and the Mann–Kendall Rank Detrended test (MKRD), which improves robustness under strong linear autocorrelation. Despite these advances, most existing methods primarily target linear dependence and do not explicitly address nonlinear behavior inherent in climate processes.

This study introduces the Mann–Kendall with Third-Order Cumulant (MKC3), a novel extension designed to capture both autocorrelation and nonlinear dependence by incorporating higher-order statistical information into the variance correction framework. Extensive Monte Carlo simulations show that no single method is universally optimal: MK performs best for independent data, TFPW preserves power but may increase false positives, SMK is suitable for weak dependence with small sample sizes, and MKRD is robust under strong linear autocorrelation.

In contrast, MKC3 demonstrates superior control of false trend detection in nonlinear settings while maintaining reasonable sensitivity to genuine trends. Application to daily rainfall and extreme rainfall indices (Rx1day and Rx5day) across Peninsular Malaysia reveals increasing trends during the Northeast Monsoon and weaker or decreasing trends during the Southwest Monsoon, highlighting the importance of selecting trend tests based on the underlying data structure to ensure reliable climate trend assessment.
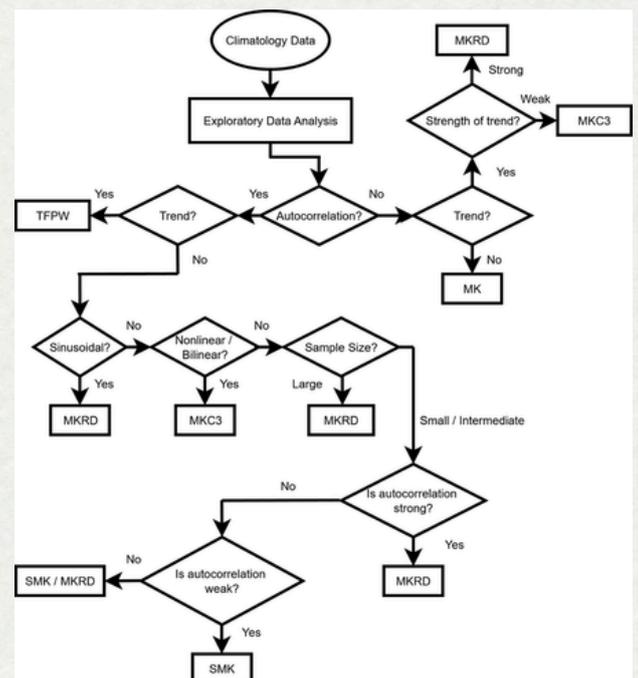

Figure 1 Flowchart presenting practical guidelines for selecting between MK and various modified MK tests based on the characteristics of time series models.

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AI-DRIVEN VISUALIZATION FOR STATISTICAL LEARNING

Assoc. Prof. Dr. Jayanthi Arasan
Department of Mathematics and Statistics,
Faculty of Science,
Universiti Putra Malaysia
Expertise: Independent Analysis
Email: jayanthi@upm.edu.my

The landscape of teaching and learning continues to evolve as technology reshapes how students process, engage with, and apply knowledge. Traditional lecture-based delivery, while foundational, often leaves learners as passive recipients of information.

Modern learners benefit greatly when statistical concepts are presented through visual and interactive methods. While traditional lectures structure the flow of knowledge, visualization and AI enhance engagement by transforming abstract formulas into meaningful representations. A structured four-step approach strengthens learning outcomes:

1. Hook - Enable visualization
2. Explore - Allow interaction
3. Analyze - Apply AI for interpretation
4. Apply - Use predictive analysis

The correlation and regression visualization tool (Figure 1) allows students to explore how regression and correlation change with different parameter settings. By adjusting the intercept, slope and error level, they can observe real-time changes in scatter patterns and regression lines. The visual response improves understanding, helping students discover relationships themselves and build stronger conceptual intuition.
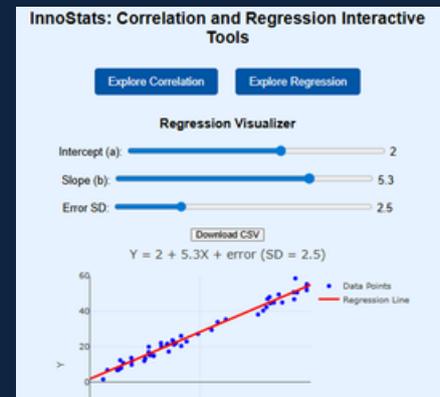

Figure 1: Interactive Regression Visualizer

The AI-driven regression interface (Figure 2) assists students in interpreting model output using natural-language explanations. This interface integrates AI assistance to generate natural-language explanations for regression results. Students may upload data, run a model, and request clarification on coefficients, confidence intervals, p-values, or implications.

The AI explains the output in accessible terms, reducing cognitive overload and enabling students to focus on understanding rather than decoding syntax. Instead of replacing analytical thinking, the tool supports students by offering guided interpretation, constructive feedback, and personalised learning.
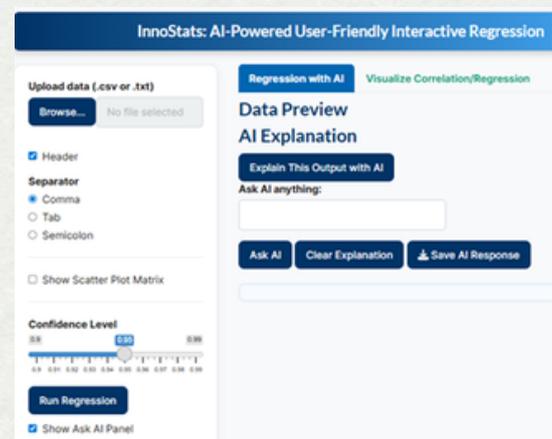

Figure 2: AI-Driven Regression Analysis Panel

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Jayanthi, A. (2021). Quick Statistical Applications with SPSS, UPM Press.

ZINC AND COPPER IN WATER SPINACH IPOMOEA AQUATICA FROM PENINSULAR MALAYSIA

Prof. Dr. Yap Chee Kong
Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
Expertise: Ecotoxicology
Email: yapchee@upm.edu.my

Water spinach Ipomoea aquatica (Figure 1) is a popular green leafy vegetable widely consumed by Malaysians. This study evaluates the bioaccumulation of zinc (Zn) and copper (Cu) in Ipomoea aquatica sampled from several agricultural areas in Peninsular Malaysia. The main focus of the research is to understand the uptake patterns of Zn and Cu by water spinach, the synergistic interactions between Zn and Cu, and their implications for food safety and environmental stability.

The analysis shows that both metals tend to bioaccumulate at higher levels in the roots compared to the stems and leaves. This indicates the important role of the plant as a phytostabilization agent. A positive relationship between Zn and Cu across plant tissues suggests that the presence of one metal may enhance the uptake of the other, particularly in areas receiving high fertilizer inputs.

From a public health perspective, the risk assessment indicates that the estimated daily intake of Zn and Cu through the consumption of I. aquatica remains below levels of concern for consumers in Malaysia. The target hazard quotient values obtained are less than one, indicating low non-carcinogenic risks of Cu and Zn at current exposure levels.

However, variation in concentrations of Cu and Zn among locations highlights the need for continuous monitoring, especially in intensively farmed agricultural areas.

Overall, the findings support the consumption of I. aquatica as a safe leafy vegetable while also demonstrating its potential role in heavy metal pollution management, which is important for sustainable agricultural practices.

Figure 1: Water spinach Ipomoea aquatica.

Reference

Wong, K. W., Yap, C. K., Nulit, R., et al. (2025). Zinc and copper in Ipomoea aquatica from Peninsular Malaysia: synergistic uptake, health risk assessment, and phytostabilization potential. International Journal of Phytoremediation.
https://doi.org/10.1080/15226514.2025.2586810

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It is a way of THINKING.

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