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2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

QUANTIFICATION OF PHOSPHATE CONTENT IN COMMERCIAL DISHWASHING DETERGENTS AVAILABLE IN MALAYSIA USING THE MOLYBDENUM BLUE METHOD

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Abstract: Phosphates are commonly used in dishwashing as water softeners, but their excessive release into water bodies contributes to eutrophication and water quality decline. Despite global regulations, phosphate-based dishwashers remain common in countries like Malaysia with minimal oversight. This study used the molybdenum blue method to quantify phosphate levels in five commercial dishwashing products (Brands A–E) sold in Malaysia. Samples were diluted (1:200), and phosphate concentrations were measured using a calibration curve (0–5 mg/L PO_4^{3-}) at 650 nm. The method showed strong linearity ($R^2 = 0.9885$) and good precision (RSD < 10%). Phosphate content ranged from 0.115 to 0.199 mg/L, with Brand E highest. Based on 5 mL usage per wash with 10–15 L water, estimated phosphate discharge ranged from 0.575 to 0.995 mg. Though low per use, repeated widespread use can increase nutrient loading in aquatic systems. Findings stress the need for awareness, regulation, and product reformulation to reduce phosphate pollution.

Keywords: *Phosphate pollution, dishwashing detergent, water quality, eutrophication, spectrophotometry*

INTRODUCTION

Dishwashing is a common household product used daily to maintain cleanliness and hygiene in the kitchen. It can remove food residues, grease, and bacteria from dishes, cutlery, and cooking utensils. It is also found in a variety of forms, including tablets, liquid, gel, powder, and paste (Contributors to Wikipedia project, 2005). It is one the most often used cleaning products in daily life, especially in homes, eating places, and businesses that deal with food. Many commercial dishwashing detergents have traditionally contained chemicals like phosphates, surfactants, and artificial fragrances. Although it is good at cleaning, it also can be harmful to human health and the environment if used excessively or disposed of inappropriately (to, 2017). The growth and metabolic functions of both plants and animals depend on phosphorus, which is a vital nutrient that greatly increases the productivity of ecosystems as an entire system. However, putting an excessive amount of phosphorus into aquatic environments, especially in the form of orthophosphate can cause major environmental issues. The main reason for phosphorus pollution is the widespread usage of chemicals based on phosphate in home dishwashing detergent. These phosphates include sodium tripolyphosphate (STPP) are frequently found in dishwashing formulations to improve cleaning effectiveness and soften hard water (Agbazue, 2014). Once discharged through domestic wastewater, phosphate compounds may enter rivers, lakes, and other water bodies to increase nutrient loads and trigger eutrophication which is a condition caused by elevated nutrient levels that promote the excessive growth of algae and aquatic plants (Pradhan, 2013). The effects of eutrophication on the ecosystem are widely known. Because it reduces light penetration, reduces dissolved oxygen during decomposition, and generates hypoxic or "dead zones" where aquatic species cannot thrive because excessive algal growth disturbs aquatic ecosystems. These conditions can harm biodiversity by degrading water quality, disturb leisure activities, and may introduce pollutants that are harmful to both human and animal health (Ismail, 2023; Agbazue, 2014). Thus, freshwater ecosystems are thought to be seriously threatened by phosphate pollution, especially in areas with few or insufficient wastewater treatment facilities.

The molybdenum blue method is one of the most popular analytical procedures. This process produces a phosphomolybdate complex when phosphate and ammonium molybdate combine in an acidic environment. A blue-colored chemical is then produced by reducing this complex using stannous chloride. At a wavelength of 650 nm,

the intensity of the produced color is precisely related to the concentration of phosphate (Pokhrel, 2013; Pradhan, 2013). This technique is suitable for analyzing phosphate levels in both natural water and dishwashing samples and it also provides reliable results even at low concentrations. This study applies the molybdenum blue method to determine phosphate concentrations in selected commercial dishwashing available in the Malaysian market. The objective is to assess whether these products meet international standards for phosphate discharge and to evaluate their potential environmental impact. Although previous studies have explored dishwashing compositions in countries there is a lack of published data focusing on dishwashing phosphate levels in Malaysia where regulations remain limited (European Cleaning Journal, 2023). This research aims to contribute to more effective regulatory strategies and raise public awareness about the environmental consequences of phosphate use. The findings may also support dishwashing manufacturers in improving product formulations and help policymakers develop appropriate standards for reducing phosphate pollution. Ultimately, the study contributes to broader efforts to protect water quality and maintain the health of aquatic ecosystems in Malaysia.

MATERIALS AND METHODS

Chemicals

All chemicals, including ammonium molybdate tetrahydrate ($(NH_4)_6Mo_7O_{24}\cdot 4H_2O$), stannous chloride dihydrate ($SnCl_2\cdot 2H_2O$), potassium dihydrogen phosphate (KH_2PO_4), sulfuric acid (H_2SO_4), and glycerine, were sourced from Sigma-Aldrich (Missouri, USA). Solutions were prepared as follows: ammonium molybdate reagent (2.5% w/v $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$ in 5 M aqueous H_2SO_4), stannous chloride solution (2.5% w/v $SnCl_2\cdot 2H_2O$ in glycerine), and phosphate stock solution (20 mg/L as PO_4^{3-} from KH_2PO_4 in aqueous solution). All aqueous solutions were prepared using sterilized deionized water (deH_2O) produced by a Sartorius Arium® Pro ultrapure water system (Göttingen, Germany). A PerkinElmer Lambda 25 UV-Visible spectrophotometer (Massachusetts, USA), equipped with 1 cm path-length quartz cuvettes, was used for absorbance measurements.

Research Design

This study employed a quantitative, laboratory-based experimental design to quantify phosphate content in commercial dishwashing detergent. The molybdenum blue method, a colorimetric technique, was selected for its high sensitivity and specificity in detecting phosphate in aqueous solutions. The method is based on the formation of a blue-coloured molybdophosphate complex, with absorbance measured at 650 nm using UV-Visible spectrophotometry.

Sample Selection

Five dishwashing detergent brands (labelled A to E) were selected from the Malaysian market. The selection was based on widespread availability and representation across major household detergent categories to ensure relevance and comparability. Only liquid formulations were included to maintain consistency in sample preparation and analysis. To maintain ethical neutrality and avoid any perception of commercial bias or endorsement, the identities of the dishwashing brands are anonymized in this study. This approach is consistent with standard academic practice, especially when brand identity is not essential to the research objectives. Standard phosphate solutions were prepared by serial dilution of the phosphate stock solution using deH_2O. Six working standards with concentrations of 0, 1, 2, 3, 4, and 5 mg/L as PO_4^{3-} were prepared to generate a calibration curve.

Preparation of Dishwashing Samples

Each dishwashing sample was diluted at a ratio of 1:200 (1 mL detergent to 200 mL tap water) to simulate typical dishwashing usage and to ensure that phosphate concentrations remained within the measurable range of the molybdenum blue method. Diluted samples were thoroughly mixed to ensure homogeneity. For both standard and dishwashing samples, 25 mL of solution was transferred into a clean container. To each sample, 1.0 mL of ammonium molybdate reagent and two drops of stannous chloride solution were added sequentially. The mixtures were gently stirred and allowed to stand for exactly 10 minutes to ensure consistent and complete colour development of the molybdophosphate complex. The 0 mg/L standard solution was used as a blank to correct for

potential reagent-related absorbance. Absorbance readings were taken at 650 nm using the UV-Visible spectrophotometer. Each measurement was performed in triplicate, and mean absorbance values were recorded. Standard deviations of the triplicate measurements were calculated to assess precision. A linear calibration curve was constructed by plotting mean absorbance values against their corresponding phosphate concentrations using Microsoft Excel. The coefficient of determination (R^2) was evaluated to confirm linearity, with R^2 values ≥ 0.98 accepted as valid.

Phosphate Determination in Dishwashing Samples

Phosphate concentrations in dishwashing samples were calculated by referencing their absorbance values to the calibration curve. Final results were expressed in mg/L, based on the linear relationship established from the standard phosphate solutions.

RESULTS AND DISCUSSION

Phosphate Calibration Curve and Analytical Performance

Standard solutions containing 0–5 mg/L of phosphate (as PO_4^{3-}) were used to create the calibration curve for phosphate quantification, which was then examined at 650 nm using the molybdenum blue method. With a coefficient of determination (R^2) of 0.9885, the calibration curve revealed a good linear relationship between absorbance and phosphate content, as illustrated in Fig. 1. This attests to the method's dependability for quantitative phosphate determination within the examined range. The relative standard deviation (RSD) for triplicate absorbance readings across the standards ranged from o.53% to 1.71%, all below the 10% threshold, indicating excellent precision and consistency. These results affirm the analytical suitability of the molybdenum blue method for detecting phosphate in liquid and paste dishwash matrices.

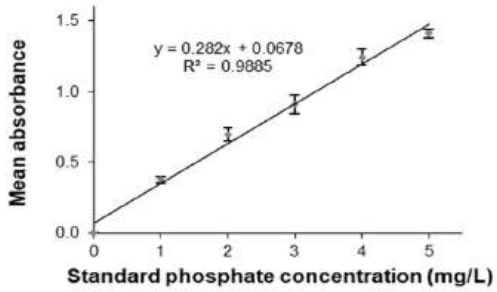


Figure 1. Linear calibration curve of mean absorbance for phosphate quantification using the molybdenum blue method. The error bars indicate the standard deviation from triplicate experiments *(n*=3).

Phosphate Quantification in Dishwashing Liquid Sample

The phosphate content of five commercial liquid and paste dishwash, labelled A trough E, was determined using the same colorimetric approach. To replicate normal household usage settings and guarantee that phosphate quantities stayed within the linear detection range, each dishwashing was diluted at a ratio of 1:200 before analysis. The results of the triple absorbance measurements for every sample are shown on Fig. 2. These measurements' satisfactory repeatability was indicated by their RSD, which varied from 0.53% to 1.71%. Different phosphate concentrations in the brands' formulations are reflected in variations in absorbance values.

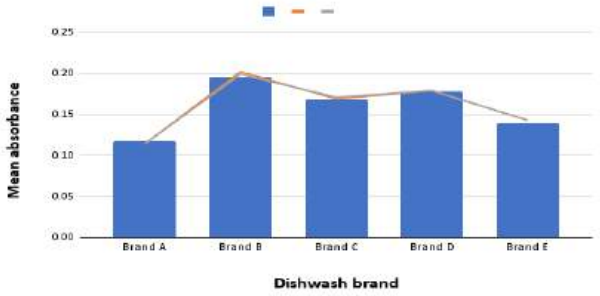


Figure 2. Mean absorbance for dishwash phosphate quantification using the molybdenum blue method. The error bars indicate the standard deviation from triplicate experiments (n = 3).

Table 1. Calculated phosphate concentrations in dishwashing samples using the molybdenum blue method

Dishwash brand	Calculated phosphate concentrations (mg/L)
A	0.115
B	0.199
C	0.169
D	0.178
E	0.141

Note: Phosphate concentrations (mg/L as PO_4^{3-}) are for 1:500 diluted dishwashing samples. They were calculated using the calibration curve (Figure 1) from standard solutions (0–5 mg/L) and average absorbance from three measurements at 650 nm (Figure 2).

Estimated Phosphate Discharge Per Wash Cycle

Based on the measured phosphate concentrations and a typical dilution of 1:200, the estimated amount of phosphate discharged per standard 50-liter wash cycle ranged from approximately 20.6 mg to 69.5 mg. These values were calculated using concentration data for each brand, where Brand A released the lowest phosphate load and Brand E the highest. All values remained well below the European Union's regulatory threshold of 500 mg of phosphate per standard dose (European Commission, 2023). However, even though the individual discharge per wash is relatively low, the cumulative effect from frequent household use can still contribute to nutrient buildup in water bodies, potentially leading to eutrophication over time (OECD, 2019). This highlights the need for continued monitoring and potential reformulation of detergent products to reduce long-term environmental impact.

Environmental Implications

Phosphates are commonly added to dishwashing detergents due to their ability to soften hard water and enhance cleaning effectiveness by breaking down grease and food residues. However, if we are using dishwashing with a high level of phosphate, it can cause a problem and negative effects. Phosphate may end up in lakes and rivers when the dishwashing detergent goes down the drain. This provides a process known as eutrophication by causing a huge quantity of algae to grow. In freshwater environments, the algae can kill fish and other aquatic life by blocking sunlight and decreasing the oxygen in the water (Contributors to Wikipedia project, 2005).

CONCLUSIONS

This study successfully applied the molybdenum blue method to measure phosphate levels in commercial dishwashing detergent. The calibration curve showed strong linearity and consistent results, and the phosphate content varied across different brands, likely due to differences in product formulation. Even though all samples were within international phosphate limits per household wash, repeated use over time could still have a negative impact on the environment (Glibert, 2022). High phosphate levels are known to cause eutrophication, which leads to

algal blooms and low oxygen zones that threaten aquatic life (OECD, 2019). One limitation of this study is the small number of samples tested, and it didn't include real wastewater discharge measurements. To reduce the environmental impact, it's recommended that manufacturers lower or eliminate phosphate in their formulations based on global environmental guidelines (European Commission, 2023). In addition, raising public awareness, enforcing regulations, and doing more research on dishwashing detergent composition and wastewater outcomes will be important to support more sustainable practices at home and protect our water ecosystems.

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Prof. Madya Dr. Nur Hisham Ibrahim
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Sekian, terima kasih.

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Setuju.

27.1.2023

PROF. MADYA DR. NUR HISHAM IBRAHIM
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SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

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