

Biological Treatment of Cafeteria Wastewater using Microbial Cultures: A Case Study at Kasetsart University

Thitima Rungratanaubon¹, Winai Puttakul²,

Yootana Mahajchariyawong³

Kewalee Singngoy¹, Salunchanok Mafutrakoon²,

and Naphatsarankon Punnisarat³

Received: June 14, 2026; Revised: June 26, 2026;

Accepted June 28, 2026; Published: June 30, 2026

Abstract

This study evaluated the effectiveness of biological enhancement using microbial cultures containing *Bacillus* spp. and lipase-producing microorganisms for improving an existing activated sludge system treating cafeteria wastewater at the Faculty of Science, Kasetsart University, Bangkok Campus, Bangkok, Thailand. The monitoring period covered June 13 to November 27, 2023. During this period, pH was measured on-site during system operation, while laboratory analyses were conducted for biochemical oxygen demand (BOD₅), fats, oils, and grease (FOG), total dissolved solids (TDS), and sulfide. The results were compared with the relevant Thai effluent standards for Type C buildings. During the early phase, approximately 3 months after first microbial application, the system exhibited signs of instability; BOD₅ remained high at 430 mg/L, and sulfide increased to 9.60 mg S²⁻/L. Following improvements to the aeration system and adjustments to the microbial dosing strategy, including direct application to the aeration tank, the final monitoring conducted on November 27, 2023, demonstrated substantial improvement. BOD₅ decreased from 1,255 to 7.40 mg/L (99.41%), FOG from 617 to 5.60 mg/L (99.09%), TDS from 1,043 to 200 mg/L (80.82%), and sulfide from 4.12 mg S²⁻/L to below the detection limit, while pH remained near neutral at 7.05. These findings indicate that microbial enhancement can improve the treatment performance and operational robustness of cafeteria wastewater treatment systems, particularly with respect to the removal of organic matter, FOG, and odor-causing sulfide.

Keywords: cafeteria wastewater; biological enhancement; activated sludge; *Bacillus* spp; fats, oils, and grease

¹Faculty of Environmental Science, Kasetsart University, Bangkok, Thailand

²Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Bangkok, Thailand

³Council of Engineers, Thailand

*Corresponding Author: thitima.r@ku.th

Introduction

Cafeteria wastewater differs from ordinary domestic wastewater because it contains food residues, readily biodegradable organic matter, detergents, and high levels of fats, oils, and grease (FOG). Excessive FOG can coat sewer lines and treatment tanks, cause blockage, generate objectionable odors, and reduce oxygen transfer into wastewater. These conditions directly affect aerobic biological treatment because activated sludge depends on stable organic loading, adequate dissolved oxygen, proper pH, hydraulic retention time, and healthy microbial flocs (Metcalf et al., 2014, Von Sperling, 2007).

The Faculty of Science cafeteria at Kasetsart University, Bangkok Campus, currently relies on an on-site wastewater treatment system that includes a grease trap or receiving tank, an equalization tank, an aeration tank, and a settling tank. Field observations prior to this study indicated persistent operational problems, including odor at the grease trap and settling units, grease accumulation, elevated BOD₅ and FOG in some monitoring events, and process instability when cafeteria activities changed. Similar canteen or restaurant wastewater studies have reported that biological systems can achieve high organic-matter removal but remain sensitive to FOG accumulation, biomass condition, aeration performance, and hydraulic retention time (Paramitha et al., 2021, Hendrasarie et al., 2021).

Bioaugmentation, or the addition of selected microbial cultures to an existing biological treatment process, is one practical option for improving treatment performance without major civil modification. *Bacillus* spp. can produce extracellular enzymes that hydrolyze proteins, starch, and lipids. At the same time, lipase-producing microorganisms can convert triglycerides

into fatty acids and glycerol, which are more readily metabolized by microbial communities. Previous studies on cafeteria grease-trap wastewater and effective microorganisms have shown that selected bacteria can improve FOG degradation and support biological wastewater treatment (Lauprasert, et al., 2017, Mohd Azmi et al., 2025).

Aeration is another critical factor because oxygen limitation can suppress aerobic degradation and favor sulfide formation. Recent work in the International Journal of Science and Innovative Technology demonstrated that improved bubble generation can substantially increase dissolved oxygen and oxygen-transfer performance, which is directly relevant to the operation of aeration units in biological treatment systems (Panich, 2024).

The objectives of this study were threefold: (1) to evaluate the effectiveness of biological enhancement using microbial cultures containing *Bacillus* spp. and lipase-producing microorganisms for treating cafeteria wastewater at the Faculty of Science, Kasetsart University; (2) to determine the removal efficiencies of BOD₅, FOG, TDS, and sulfide and to evaluate pH after treatment; and (3) to compare the treated-water quality with applicable Thai building-effluent standards and identify operational issues requiring further monitoring.

This study also aligns with Kasetsart University's Green University initiative, which emphasizes environmental management, water resource management, wastewater treatment, water reuse, and the reduction of environmental impacts on campus (Kasetsart University, n.d., Kasetsart University, 2020). Therefore, treating cafeteria wastewater at its source represents not only a local operational improvement but also an important component of sustainable campus management.

Methodology

1. Study Area and Existing Wastewater Treatment System

The study was conducted at the wastewater treatment system of the Faculty of Science cafeteria, Kasetsart University, Bangkok Campus, Bangkok, Thailand. The existing treatment system was Activated Sludge consisting of a grease trap (primary receiving unit), an equalization tank, an aeration tank functioning as the core activated sludge unit, and a settling tank prior to discharge. Wastewater monitoring focused on Pond 1 as the influent sampling point and Pond 4 as the final effluent sampling point.

2. Microbial Cultures and Dosing Scheme

The microbial product used in this study was developed through a research collaboration between the Faculty of Science, Kasetsart University, and a private company. The product consisted of *Bacillus* spp. and other associated microorganisms, including lipase-producing microorganisms, which are known for their potential to degrade organic matter. It was prepared in both liquid and powder forms to support odor reduction and lipid degradation. The initial dose applied during Week 1 consisted of 12 L of liquid culture and 5 kg of powder culture. From Week 2 onward, the regular dosage was adjusted to 8 L of liquid culture and 3 kg of powder culture per week. Microbial cultures were primarily applied to the grease trap (Pond 1) and the settling tank (Pond 4). However, during the final monitoring period, the microbial dosing strategy was modified to improve treatment performance, with Pond 3 included as an additional location for microbial application.

3. Sampling and Analytical Parameters

The research period covered 6 months from June to November 2023, and field monitoring was conducted from June 13 to November 27, 2023, corresponding to 22 weeks of system operation and adjustment. The field parameter was pH. Laboratory parameters were BOD₅, FOG, TDS, and sulfide. Units were standardized as mg/L for BOD₅, FOG, and TDS, and mg S²⁻/L for sulfide. Analytical methods were interpreted according to the Standard Methods framework for water and wastewater analysis [1].

4. Removal Efficiency and Standards Comparison

Removal efficiency was calculated using the influent concentration (C_{in}) and effluent concentration (C_{out}) according to Equation (1).

$$\text{Removal efficiency (\%)} = [(C_{in} - C_{out}) / C_{in}] \times 100. \dots (1)$$

where C_{in} is the concentration of the influent wastewater (sampled from Pond 1), and C_{out} is the concentration of the treated effluent (sampled from Pond 4). The pH parameter was not included in the removal-efficiency calculation because it does not represent pollutant concentration. Instead, pH was evaluated to assess its suitability for microbial activity and compliance with applicable effluent standards.

The standard values used in this study were based on the 2024 Thai notification on effluent standards for certain types and sizes of buildings issued by the Pollution Control Department (Table 1) (Pollution Control Department, 2024).

Table 1 Tested parameters and reference standards used for comparison.

Parameter	Unit	Standard/reference value	Role in the study
pH	-	5.5-9.0	Microbial suitability and legal compliance
BOD ₅	mg/L	≤40	Biodegradable organic matter
Sulfide	mg S ²⁻ /L	≤3.0	Odor and anaerobic-condition indicator
TDS	mg/L	≤1,200 (Type C)	Dissolved-solids indicator
FOG	mg/L	≤20	Key cafeteria wastewater parameter

Results and discussion

Table 2 summarizes the removal efficiencies of the investigated parameters and their compliance with the applicable reference standards. The results and discussion in the following sections are based on these findings.

1. System Conditions Before and During Microbial Enhancement

System condition was assessed primarily through pH and the response of key wastewater parameters during the monitoring period. Influent pH values ranged from 5.28 to 5.82, indicating mildly acidic wastewater at times. After biological enhancement and operational adjustments, treated-water pH approached neutral conditions, ranging from 6.90 to 7.20 in the monitored treated-water tanks. This range is suitable for aerobic microbial activity and falls within the reference pH range for building effluent. Maintaining this pH range is important because enzyme production, microbial metabolism, and floc stability in activated sludge can deteriorate under strongly acidic or alkaline conditions (Metcalf et al., 2014, Von Sperling, 2007).

The monitoring results also show that the system did not immediately stabilize after microbial addition. The September 6, 2023, monitoring event showed poor BOD₅ and sulfide

performance and an increase in TDS from influent to treated water. This pattern suggests that process control, especially grease management and aeration, was still insufficient at that time. After the aeration unit was improved and the dosing plan was adjusted to include the aeration tank, the final monitoring event showed much stronger treatment performance.

2. BOD₅ Removal and Biodegradable Organic Matter

BOD₅ is the main indicator of biodegradable organic pollution in cafeteria wastewater. On July 12, 2023, BOD₅ decreased from 570 to 55.75 mg/L, corresponding to 90.22% removal, but the treated water still exceeded the 40 mg/L reference value. On August 24, 2023, BOD₅ removal was high at 96.49%, decreasing from 2,050 to 72 mg/L, but again did not meet the reference standard. On September 6, 2023, removal dropped sharply to 4.44%, with BOD₅ decreasing only from 450 to 430 mg/L. This result confirms a period of severe process instability, likely associated with high organic or grease loading, insufficient aeration, or poor biomass condition. The final monitoring event on November 27, 2023, demonstrated substantial improvement in treatment performance. BOD₅ decreased from 1,255 to 7.40 mg/L, corresponding to a removal efficiency of

99.41% and meeting the reference standard of 40 mg/L. This result suggests that the combined optimization of microbial dosing and aeration management contributed to the recovery and stabilization of the biological treatment process. Similar studies on canteen and restaurant wastewater have reported high BOD and COD removal efficiencies when adequate biomass acclimatization and appropriate operating conditions, particularly aeration, were maintained (Hendrasarie, et al., 2021, Paramitha et al., 2021).

3. FOG Removal

FOG was the most consistently improved parameter in this study. On July 12, 2023, FOG decreased from 1,259.66 to 5.00 mg/L, corresponding to 99.60% removal. On August 24, 2023, FOG decreased from 799.56 to 5.33 mg/L, or 99.33% removal. On November 27, 2023, FOG decreased from 617 to 5.60 mg/L, or 99.09% removal. All reported treated-water FOG concentrations were below the 20 mg/L reference value.

The high FOG removal is consistent with the expected role of lipase-producing microorganisms. Lipases hydrolyze triglycerides in fats and grease into fatty acids and glycerol, after which microorganisms can use these compounds as carbon sources. This mechanism can reduce grease accumulation, lower the risk of clogging, and indirectly support activated sludge stability. Prior studies on cafeteria grease traps have reported that selected bacteria can contribute to FOG degradation, and recent work on effective microorganisms also supports their use in wastewater treatment contexts (Lauprasert, et al., 2017, Mohd Azmi et al., 2025).

4. TDS and Sulfide Removal

TDS exhibited both removal and fluctuations throughout the study period. TDS decreased from 626 to 360 mg/L on July 12, 2023, and from 888 to 442 mg/L on August 24, 2023. However, on September 6, 2023, TDS increased from 536 to 812 mg/L, corresponding to a negative removal efficiency of -51.49%. Although this increase did not exceed the Type C effluent standard of 1,200 mg/L and therefore did not indicate regulatory noncompliance, it suggests instability in the treatment process and highlights the importance of monitoring source-water TDS in addition to wastewater TDS. The final monitoring event on November 27, 2023, demonstrated substantial improvement, with TDS decreasing from 1,043 to 200 mg/L, corresponding to a removal efficiency of 80.82%.

Sulfide was closely linked to odor and anaerobic conditions. Sulfide decreased from 9.80 to 2.67 mg S^{2-} /L on July 12, 2023, and from 5.56 to 1.51 mg S^{2-} /L on August 24, 2023, both passing the 3.0 mg S^{2-} /L reference value. On September 6, 2023, sulfide increased from 8.73 to 9.60 mg S^{2-} /L after treatment, indicating that anaerobic or oxygen-limited conditions persisted in part of the system. By November 27, 2023, sulfide decreased from 4.12 mg S^{2-} /L to not detected. This result is consistent with improved aeration and biological oxidation capacity (Hernández-Aguilar et al., 2022, Panich, 2024).

Table 2 Removal efficiency of monitored parameters during the study period.

Date	Parameter	C _{in}	C _{out}	Removal (%)	Standard	Status
12 Jul 2023	pH	5.28	6.90	-	5.5-9.0	Pass
12 Jul 2023	BOD ₅	570	55.75	90.22	≤40 mg/L	Not pass
12 Jul 2023	FOG	1,259.66	5.00	≥99.60	≤20 mg/L	Pass
12 Jul 2023	TDS	626	360	42.49	≤1,200 mg/L	Pass (conc.)
12 Jul 2023	Sulfide	9.80	2.67	72.76	≤3.0 mg S ²⁻ /L	Pass
August 24 2023	pH	5.82	6.97	-	5.5-9.0	Pass
August 24 2023	BOD ₅	2,050	72.00	96.49	≤40 mg/L	Not pass
August 24 2023	FOG	799.56	5.33	99.33	≤20 mg/L	Pass
August 24 2023	TDS	888	442	50.23	≤1,200 mg/L	Pass (conc.)
August 24 2023	Sulfide	5.56	1.51	72.84	≤3.0 mg S ²⁻ /L	Pass
September 6 2023	pH	5.65	7.20	-	5.5-9.0	Pass
September 6 2023	BOD ₅	450	430	4.44	≤40 mg/L	Not pass
September 6 2023	FOG	51.60	ND	≥90.31*	≤20 mg/L	Pass
September 6 2023	TDS	536	812	-51.49	≤1,200 mg/L	Pass (conc.); process increase
September 6 2023	Sulfide	8.73	9.60	-9.97	≤3.0 mg S ²⁻ /L	Not pass
November 27 2023	pH	5.53	7.05	-	5.5-9.0	Pass
November 27 2023	BOD ₅	1,255	7.40	99.41	≤40 mg/L	Pass
November 27 2023	FOG	617	5.60	99.09	≤20 mg/L	Pass
November 27 2023	TDS	1,043	200	80.82	≤1,200 mg/L	Pass (conc.)
November 27 2023	Sulfide	4.12	ND	≈100*	≤3.0 mg S ²⁻ /L	Pass

Note. ND = not detected.

5. Overall Performance and Green University Implications

Overall, the biological enhancement program improved the cafeteria wastewater treatment system after the operational adjustment phase. The strongest evidence is the final monitoring

result, where BOD₅, FOG, TDS, sulfide, and pH all met the selected reference values. FOG removal was consistently high throughout the study, but BOD₅ and sulfide performance indicated that microbial addition alone is insufficient if aeration, grease management, and organic loading are not

controlled. This is an important practical finding: bioaugmentation should be treated as an operational tool within a controlled activated sludge process, not as a substitute for proper system operation.

In the Green University context, the approach can reduce organic loading, oil and grease, and sulfide-causing odor before discharge to public drainage. It may also reduce pipe clogging and maintenance demand. Nevertheless, water reuse or formal compliance decisions require a broader monitoring package, especially TSS, dissolved oxygen in the aeration tank, flow rate, sludge condition, and paired source-water TDS. Without these parameters, the study can demonstrate performance improvement, but it cannot fully substitute for regulatory monitoring.

Conclusion

Biological enhancement using microbial cultures containing *Bacillus* spp. and lipase-producing microorganisms improved the performance of the existing activated sludge system treating cafeteria wastewater at the Faculty of Science, Kasetsart University. After system adjustment, final monitoring showed that BOD₅ decreased by 99.41%, FOG by 99.09%, TDS by 80.82%, and sulfide was not detected, while pH was

maintained near neutral. These results indicate strong treatment potential for organic matter, Fat, oil and grease, dissolved solids, and odor-related sulfide under improved operating conditions.

The study also showed that the system was unstable during the early operating period. Around 3 months after treatment, BOD₅ and sulfide exceeded the reference values, while TDS increased from influent to treated water. This confirms that microbial enhancement must be combined with adequate aeration, grease control, and proper dosing management. The findings support the use of biological enhancement as a practical measure for campus wastewater management and Green University implementation, but further monitoring is needed to confirm long-term performance and full regulatory compliance at the final discharge point.

Acknowledgement

The authors would like to express their sincere gratitude to the Faculty of Science, Kasetsart University, and its private-sector partner for their support of this study. Appreciation is also extended to all personnel involved in field data collection, the operation and maintenance of the cafeteria wastewater treatment system, and water quality analysis.

Reference

- Hendrasarie, N., Nugraha, M. Y. C., & Fadilah, K. (2021). Restaurant wastewater treatment with a two-chamber septic tank and a sequencing batch reactor. *E3S Web of Conferences*, 328, 01011. <https://doi.org/10.1051/e3sconf/202132801011>
- Hernández-Aguilar, H., García-Lara, C. M., Nájera-Aguilar, H. A., Gutiérrez-Hernández, R. F., Martínez-Salinas, R. I., & Araiza-Aguilar, J. A. (2022). Evaluation of the toxicity of cafeteria wastewater treated by a coupled system (ARFB-SD). *Processes*, 10(8), 1442. <https://doi.org/10.3390/pr10081442>

Kasetsart University Green Campus. (n.d.). PLANET. <https://greencampus.ku.ac.th/homepage/planet/>

Kasetsart University Green Campus. (2020). 3.3 Disposal of organic solid waste.

<https://greencampus.ku.ac.th/3-3-2020/>

Lauprasert, P., Chansirattana, J., & Paengjan, J. (2017). Effect of selected bacteria as bioremediation on the degradation of fats, oils, and greases in wastewater from cafeteria grease traps. *European Journal of Sustainable Development*, 6(2), 181–186. <https://doi.org/10.14207/ejsd.2017.v6n2p181>

Mohd Azmi, N. A. A., Saidon, N. Z., Jamaludin, N. N. N., & Yahya, I. (2025). Comprehensive study of effective microorganisms in wastewater treatment. *Multidisciplinary Applied Research and Innovation*, 6(4), 99–103. <https://doi.org/10.30880/mari.2025.06.04.014>

Panich, P. (2024). Effect of using a bubble generator on aeration efficiency in a closed fish tank.

International Journal of Science and Innovative Technology, 7(1).

<https://ph01.tci-thaijo.org/index.php/IJSIT/article/view/255349>

Paramitha, T., Sukmana, A. F., Rifa'i, A. F., Budiastuti, H., Ghazali, M., & Sudarman, R. (2021). Canteen wastewater treatment using activated sludge and added bioballs. In *Proceedings of the 2nd International Seminar of Science and Applied Technology (ISSAT 2021)* (pp. 333–338). Atlantis Press. <https://doi.org/10.2991/aer.k.211106.053>

Pollution Control Department. (2024, September 10). Notification of the Ministry of Natural Resources and Environment on effluent standards for certain types and sizes of buildings B.E. 2567. Ministry of Natural Resources and Environment. <https://www.pcd.go.th/laws/32973/>

Tchobanoglous, G., Stensel, H. D., Tsuchihashi, R., & Burton, F. L. (2014). *Wastewater engineering:*

Treatment and resource recovery (5th ed.). McGraw-Hill Education.von Sperling, M. (2007).

**Wastewater characteristics, treatment and disposal* (Vol. 1). IWA Publishing.