

Characterization of SPPG Wastewater for Treatment Planning in Sleman Regency

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Abstract

The Free Nutritious Meal Program generates kitchen wastewater containing organic matter, suspended solids, oil and grease, and microorganisms. This study characterized wastewater from 10 SPPG facilities across 10 sub-districts in Sleman Regency based on BOD, COD, TSS, oil and grease, and total coliform, and compared the results with applicable standards under Minister of Environment and Forestry Regulation No. 11 of 2025. Results showed substantial variation, with TSS of 121–7,340 mg/L, BOD 91–1,445 mg/L, COD 829–8,078 mg/L, oil and grease <0.2–168.4 mg/L, and total coliform exceeding 16×10^8 MPN/100 mL at most locations. Most parameters exceeded the applicable standards. Higher pollutant concentrations tended to occur at facilities with higher production volumes and fried-food menus, although these relationships were based on observed patterns rather than statistical testing. The findings provide baseline wastewater characteristics for SPPGs in Sleman Regency and support treatment planning, particularly the use of grease traps as pretreatment before biological processes. The study is limited by a single sampling event at each facility.

Keywords: SPPG, Kitchen Wastewater, Wastewater Characterization, Pollutant Load, Free Nutritious Meal (MBG) Program

INTRODUCTION

The Free Nutritious Meal Program (MBG) is an Indonesian government initiative providing meals at large scale to improve nutritional status. Its centralized food production generates kitchen wastewater containing organic matter, suspended solids, oil and grease, and microorganisms, with characteristics influenced by food types, production intensity, and cleaning practices (Meliana et al., 2025). Without adequate treatment, these pollutants may water quality and public health, highlighting the importance of wastewater management in supporting Sustainable Development Goal (SDG) 6. However, information on SPPG wastewater under the MBG Program remains limited.

This study characterizes wastewater from 10 SPPGs in Sleman Regency, Special Region of Yogyakarta, based on BOD, COD, TSS, oil and grease, and total coliform, and compares the results with applicable standards under Minister of Environment and Forestry Regulation No. 11 of 2025. It examines wastewater characteristics, variations associated with production capacity and menu composition, and compliance with applicable standards. The study hypothesizes that higher production capacity and fried-food menus are associated with higher pollutant concentrations, particularly organic matter, suspended solids, and oil and grease. One sample was collected from each facility, with operational characteristics assessed descriptively.

LITERATURE REVIEW

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Non-Hazardous and Non-Toxic Waste

SPPG kitchen wastewater is classified as non-B3 under Government Regulation No. 22/2021, but its organic matter, solids, oil and grease, and microorganisms may pose environmental and health risks if discharged untreated (Pemerintah Indonesia, 2021; [Kementerian Kesehatan RI, 2011](#)). Therefore, treatment is required before discharge.

Characteristics of SPPG Kitchen Waste Water

SPPG kitchen wastewater from food preparation, utensil washing, and area cleaning contains food residues, organic matter, suspended solids, and fats, with characteristics varying by facility scale, food type, and water use ([Garza et al., 2005](#)).

Chemical Parameters

1. BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand)

BOD and COD represent biodegradable and chemically oxidizable organic matter and are important for biological treatment design, including biofilter systems ([Santoso, 2018](#); [Lumaela et al., 2013](#); [Hermawanto & Sugito, 2018](#)). COD is also widely reported in kitchen wastewater studies (Gurd, Jefferson, & Villa, 2019), with concentrations ranging from 2,229 mg/L in the Caribbean ([Cudjoe et al., 2024](#)) to 1,784–7,196 mg/L in South Africa, alongside BOD₅ of 1,101–3,222 mg/L ([Rapeta, 2021](#)). Malaysian restaurant wastewater has also been reported to exceed local COD and BOD standards ([Ahmad et al., 2023](#)). These variations show that wastewater characteristics are site-specific, supporting the need for local characterization before establishing SPPG treatment design assumptions.

2. Oil and Grease

High oil and grease concentrations can inhibit biological treatment by reducing oxygen transfer. Therefore, pretreatment with a grease trap is required before biological treatment. Grease traps operate based on density differences and can separate oils and fats with efficiencies of up to 91% ([Priyambada & Purwono, 2019](#)). High concentrations of oil and grease can decrease oxygen transfer into the liquid mass, so pretreatment using a grease trap is generally necessary before wastewater enters the biological unit ([Idham & Abdullah, 2021](#); [Ali, Abu Talib, & Syed Hashim, 2022](#)). In restaurant wastewater in Malaysia, FOG is also consistently reported as a high parameter ([Ahmad et al., 2023](#)).

Physical Parameter: Total Suspended Solid (TSS)

TSS represents suspended solids in wastewater may require preliminary sedimentation before biological treatment (Tchobanoglous, Burton, & Stensel, 2003). Institutional kitchen wastewater in the Caribbean had an average TSS of about 446 mg/L ([Cudjoe, Banerjee, & Cooper, 2024](#)), while Malaysian restaurant wastewater showed high TSS concentrations exceeding local standards ([Ahmad et al., 2023](#)). Food court wastewater in South Africa also contained elevated solids ([Rapeta, 2021](#)).

Microbiology Parameter: Total Coliform

Total coliform indicates biological contamination in wastewater (Ministry of Health of the Republic of Indonesia, 2011). Food court wastewater in South Africa showed total coliform up to 9.1×10^3 CFU/mL, while treated WWTP effluent in West Sumatra ranged from <18–1,700 MPN/100 mL, below the 3,000 MPN/100 mL standard ([Rapeta, 2021](#); [Ananda & Ahda, 2026](#)). These findings highlight the need for biological treatment and disinfection of SPPG wastewater.

Previous Studies and Research Gap

Kitchen wastewater commonly contains high COD, BOD, solids, nutrients, and FOG concentrations (Ahmad et al., 2023; Shamika et al., 2024). Previous studies have focused mainly on commercial restaurants and household or small-to-medium food-service facilities (Ahmad et al., 2023; Cudjoe et al., 2024; Akbar & Silmi, 2021; Aniska et al., 2022). However, data on institutional kitchen wastewater produced at the mass scale of SPPG remain limited. This study therefore characterizes SPPG wastewater in Sleman Regency and assesses its pollutant characteristics against applicable standards.

RESEARCH METHODOLOGY

Wastewater sampling and laboratory analysis were conducted at 10 SPPGs in Sleman Regency. Locations were purposively selected based on subdistrict population, with one SPPG representing each of the 10 most populous subdistricts to capture wastewater characteristics from facilities serving relatively large populations across Sleman Regency (Table 1).

Sampling Method

Wastewater samples were collected once from 10 SPPGs at approximately 14:00 WIB after meal service and cleaning activities. Samples were taken from washing wastewater before mixing with other sources, with approximately 1,000 mL collected according to applicable laboratory methods. One SPPG from each of the 10 sub-districts was sampled over 10 days to represent kitchen wastewater characteristics in areas of Sleman Regency (Figure 1).

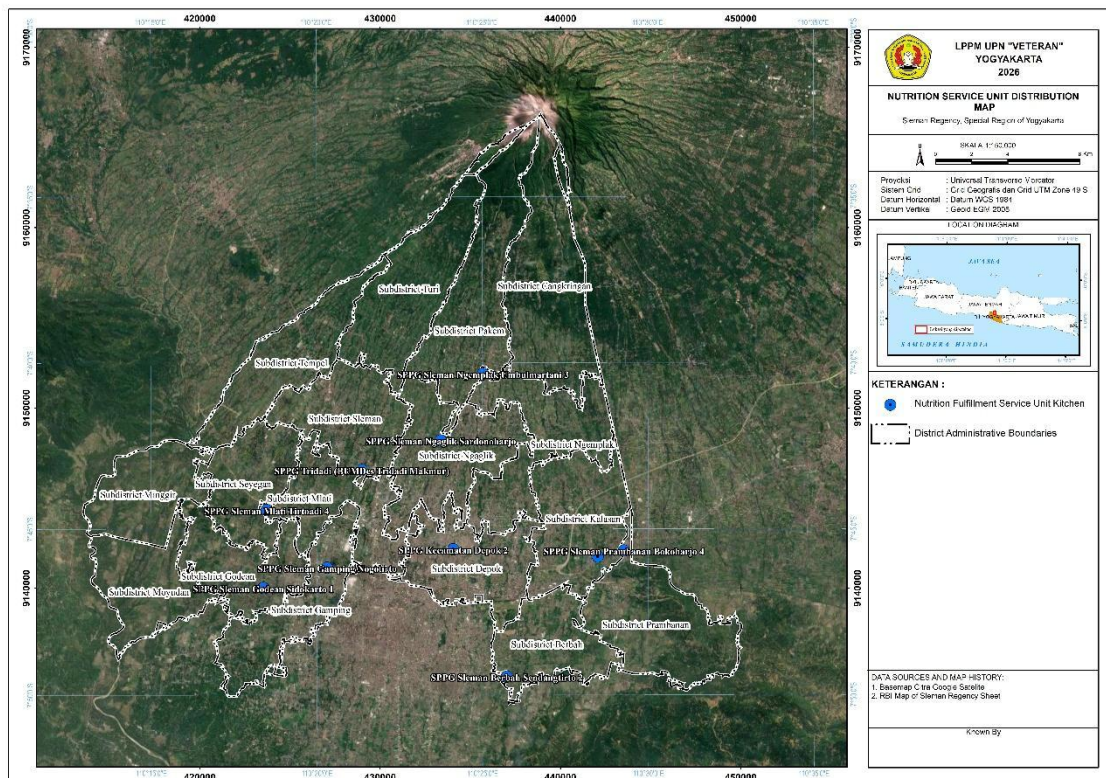


Figure 1. Map Distribution Of SPPG

Table 1. The Highest Population in Sleman Regency

Subdistrict	People
Depok	20855
Berbah	20342
Prambanan	14009
Gamping	12305
Kalasan	10925
Mlati	10462
Godean	8231
Ngaglik	8142
Sleman	7654
Ngemplak	6859

(Source: BPS Sleman Regency)

Laboratory Analysis

Samples were analyzed for total coliform, BOD, COD, oil and grease, and TSS, representing characteristics of kitchen wastewater. Table 2 presents the analytical methods and units. Laboratory analyses were performed by *Balai Laboratorium Lingkungan Dinas Lingkungan Hidup dan Kehutanan* (DLHK) Yogyakarta.

Table 2. Parameter and Laboratory Analysis Method

No	Parameter	Unit	Method
Microbiology			
1	Total Coliform	MPN/100ml	APHA Section 2005 9221 B
Chemical			
1	BOD	Mg/L	SNI 6989.72:2009
2	COD	Mg/L	SNI 6989.2:2019
3	Oil and Grease	Mg/L	SNI 6989-10:2011
Physical			
1	TSS	Mg/L	SNI 6989.3:2019

Data from the survey and laboratory analysis were evaluated descriptively to compare wastewater characteristics among locations. Survey information was used to explain differences in pollutant concentrations. The results were compared with the applicable wastewater quality standards under Regulation of the Minister of Environment and Forestry No. 11 of 2025.

Table 3. The effluent quality standards

Parameter	Unit	Quality Standard
BOD	mg/L	50
COD	mg/L	100
TSS	mg/L	50
Oil and Grease	mg/L	10
Total Coliform	MPN/100 ml	1000

Survey and Data Analysis

A structured survey covered production capacity, wastewater management, and menu characteristics, with menus classified by dominant food types and processing methods. Survey and laboratory data were descriptively compared among SPPGs. Sampling and interviews were conducted with SPPG management approval. The study was limited by purposive site selection and a single sampling event during one operating period at each SPPG, which may not capture daily or seasonal variations.

FINDINGS AND DISCUSSION

Characteristics of Wastewater of SPPGs

SPPG wastewater characteristics are influenced by operational activities that affect water use and pollutant generation, including the number of food portions produced and menu variety. These factors reflect the intensity and characteristics of kitchen activities. Data on food portions are presented in Table 4.

Table 4. Number of Food Portions Served by SPPGs in 10 Subdistricts of Sleman Regency

No	Subdistricts	Number of Portions
1.	Depok	1700
2.	Berbah	1732
3.	Prambanan	1800
4.	Gamping	2913
5.	Kalasan	3086
6.	Mlati	3150
7.	Godean	2600
8.	Ngaglik	3000
9.	Sleman	3200
10.	Ngemplak	2880

SPPG wastewater characteristics are influenced by operational activities, including food production volume and menu variety, which affect water use and pollutant generation. Food portion data are presented in Table 4.

Table 5. Food Menus Served at SPPGs in Sleman Regency

Subdistrict	Food Menu
Depok	Fish katsu, rice, braised tofu in sweet soy sauce, melon, sautéed green beans and carrots
Berbah	Fried chicken, fried tempeh, watermelon, stir-fried green beans
Prambanan	Rice, chicken curry, fried tempeh, stir-fried green beans and carrots, watermelon
Gamping	Grapes, rice, fried tempeh, fried catfish, lalapan
Kalasan	Rice, mendoan tempeh, melon, stir-fried green beans, chicken stew
Mlati	Rice, fried egg, mendoan tempeh, longan, stir-fried long beans, carrots
Godean	Stir-fried cauliflower with mushrooms, braised tofu, crispy chicken fillet, banana rice
Ngaglik	Rice, fried chicken, sweet-marinated tofu, stir-fried long beans, banana
Sleman	Smashed spicy fried chicken, fried tempeh, dragon fruit, rice
Ngemplak	Stir-fried carrots and pakcoy, sweet soy sauce-braised chicken, crispy tofu watermelon, rice

Laboratory results from 10 SPPGs are presented in Table 6.

Table 6. Laboratory Test Results of SPPG Wastewater Quality

Sample	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Oil&Grease (mg/L)	Total Coliform (MPN/100mL)
Depok	559	388	1.273	16,4	$>16 \times 10^8$
Berbah	197	416	1.389	8,8	$>16 \times 10^8$
Prambanan	1.653	1.406	3.193	<0,2	$>16 \times 10^8$
Gamping	433	340	1.183	24,6	28×10^7
Kalasan	121	632	1.023	4,8	$>16 \times 10^8$
Mlati	7.340	434	8.078	154,8	$>16 \times 10^8$
Godean	185	91	829	4,2	$>16 \times 10^8$
Ngaglik	198	127	961	3,4	$>16 \times 10^8$
Sleman	6.520	1.445	6.942	168,4	$>16 \times 10^8$
Ngemplak	183	350	969	7,8	$>16 \times 10^8$

Wastewater variation was consistent with previous studies showing that food-service wastewater characteristics depend on establishment size, meal types, and cleaning practices (Gurd et al., 2019). Lesikar et al. (2006) reported typical BOD₅, TSS, and FOG concentrations of 1,523, 664, and 197 mg/L, respectively. In this study, TSS ranged from 121–340 mg/L, BOD 91–445 mg/L, COD 829–078 mg/L, and oil and grease <0.2–168 mg/L. Pollutant concentrations were not directly proportional to production volume, while higher TSS at Mlati and Sleman highlights the importance of suspended solids in treatment design. These findings indicate that menu composition and food preparation and cleaning practices, in addition to production volume, influence wastewater characteristics (Gurd et al., 2019). Therefore, treatment planning should consider both production volume and kitchen operational characteristics.

Menu Classification Based on Food Processing Methods

To assess the relationship between menu types and wastewater characteristics, the menus presented in Table 7 were classified based on the dominant cooking method into three categories: fried-dominant (≥ 2 fried dishes), mixed (one fried dish combined with stir-fried or stewed dishes), and non-fried (without fried dishes).

Table 7. Categorization of Menus in SPPGs

No	Sub district	Menu Category	Fried Menu Items
1.	Depok	Mixed Menus	Fish Katsu
2.	Berbah	Dominated by fried foods	Fried chicken, fried tempeh
3.	Prambanan	Mixed Menus	Fried tempeh with coriander
4.	Gamping	Dominated by fried foods	Fried tempeh, fried catfish fillet in batter
5.	Kalasan	Mixed Menus	Tempeh mendoan
6.	Mlati	Dominated by fried foods	Sunny-side-up egg, Tempeh mendoan
7.	Godean	Mixed Menus	Crispy chicken fillet
8.	Ngaglik	Mixed Menus	Fried chicken
9.	Sleman	Dominated by fried foods	Smashed spicy fried chicken, fried tempeh

No	Sub district	Menu Category	Fried Menu Items
10.	Ngemplak	Stir-fried and Braised Dishes	-

SPPGs with fried-food menus (Gamping, Sleman, Berbah, and Mlati) showed higher average oil and grease concentrations (8.8–168.4 mg/L) than mixed-menu SPPGs (Prambanan, Depok, Godean, Ngaglik, and Kalasan; <0.2–16.4 mg/L), indicating the influence of frying activities on FOG generation. This is consistent with [Ahmad et al. \(2023\)](#), who associated FOG with food residues and cooking, particularly fried foods, while Gurd et al. (2019) noted that emulsified FOG may limit simple physical separation. Pollutant concentrations were not directly proportional to production volume, as medium-volume SPPGs (2,600–3,086 portions/day) generally showed lower TSS, BOD, and COD than the highest-volume sites. These findings indicate that menu composition and food processing practices, alongside production volume, influence wastewater characteristics.

Physical Characteristics of Wastewater from Nutrition Service Units

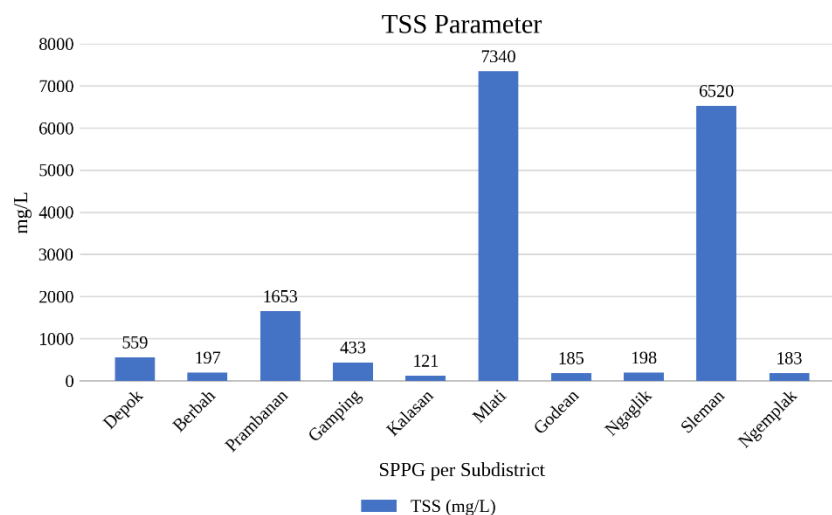


Figure 2. TSS concentrations in Kitchen Wastewater of SPPG per District

TSS concentrations ranged from 121 mg/L in Kalasan to 7,340 mg/L in Mlati. Mlati, Sleman, and Prambanan exceeded the 664 mg/L design value reported by Lesikar et al. (2006), indicating substantial suspended-solids loading requiring pretreatment. High TSS at Mlati and Sleman coincided with high production volumes (3,150 and 3,200 portions/day) and solid food residues, while Kalasan had the lowest TSS despite producing 3,086 portions/day. This suggests that menu composition and food residues, rather than production volume alone, influence TSS. Source control, particularly removal of coarse food residues, is therefore important before wastewater enters the drainage system.

Chemical Characteristics of Wastewater from Nutrition Service Units.

a. BOD

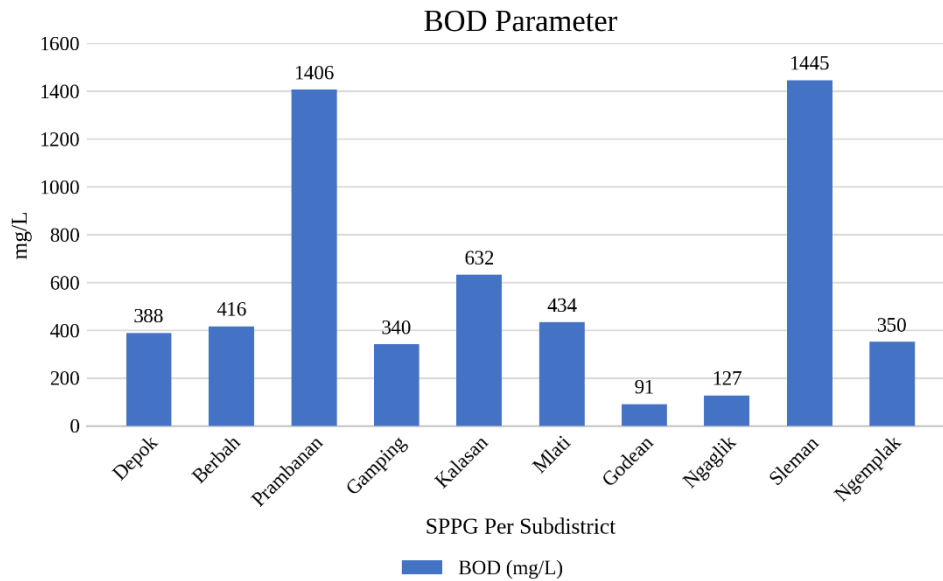


Figure 3. Concentration of BOD in Kitchen Wastewater of SPPG per District.

BOD concentrations ranged from 91 mg/L in Godean to 1,445 mg/L in Sleman, with elevated values in Prambanan (1,406 mg/L) and Kalasan (632 mg/L). These values indicate substantial biodegradable organic loads from food residues and preparation and washing activities (Ramadani et al., 2021). They are comparable to food-service wastewater, with a mean BOD_5 of $1,040 \pm 690$ mg/L and a design value of 1,523 mg/L, and a maximum of 3,170 mg/L reported by Ahmad et al. (2023). Thus, SPPG wastewater should not be considered low-strength domestic greywater in IPAL design. BOD was not directly proportional to production volume, as Prambanan recorded high BOD despite lower production, while Godean had the lowest BOD despite approximately 2,600 portions/day. This indicates that menu composition and food preparation practices also influence biodegradable organic loads.

b. COD

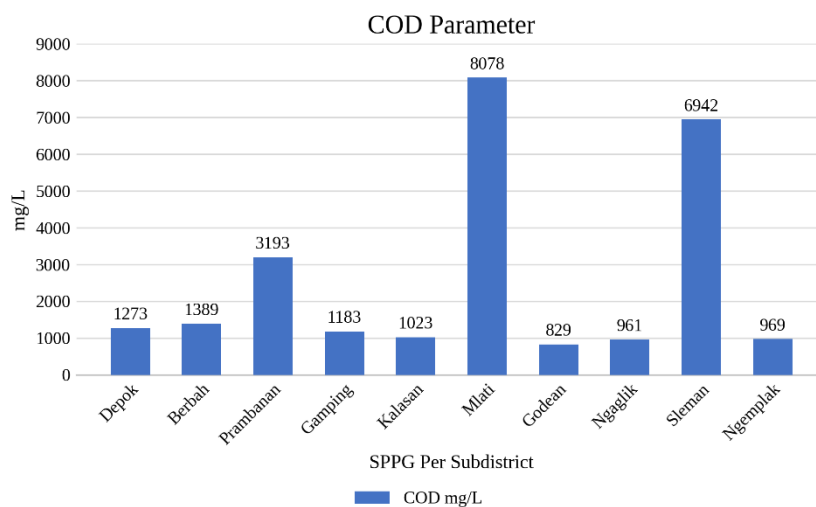


Figure 4. Konsentrasi COD pada Air Limbah Dapur SPPG per Kecamatan

COD concentrations ranged from 829–8,078 mg/L, with the highest value in Mlati and the lowest in Godean. High COD indicates substantial chemically oxidizable material from food residues and processing activities (Ramadani et al., 2021). Elevated COD at Mlati and Sleman coincided with high BOD, TSS, and production volumes, while frying may further contribute through oil residues and thermal degradation products. Godean's lower COD and BOD may reflect its predominance of stir-fried and boiled menus. The Mlati COD was comparable to the maximum reported in Malaysian restaurant wastewater (9,948 mg/L; Ahmad et al., 2023), while Depok and Gamping were comparable to UK food-service wastewater ($1,400 \pm 560$ mg/L; Gurd et al., 2020). These findings show that SPPG wastewater can exhibit COD levels comparable to commercial food-service wastewater.

c. Oil and Grease

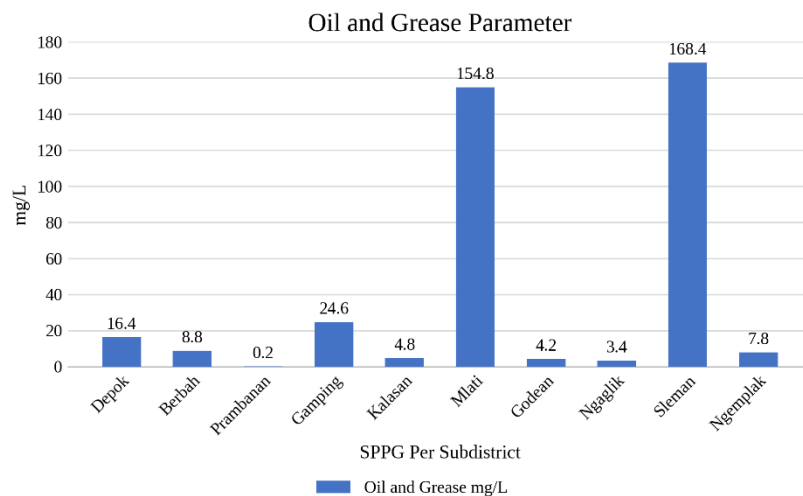


Figure 5. Konsentrasi Oil and Grease pada Air Limbah Dapur SPPG per Kecamatan

Oil and grease concentrations ranged from <0.2 mg/L in Prambanan to 168.4 mg/L in Sleman. Higher FOG levels were associated with fried-food preparation and influenced by food type and cleaning practices (Ahmad et al., 2023). Detergents may further emulsify FOG, reducing its separation (Gurd et al., 2020). Although the maximum concentration was below 197 mg/L, emulsified FOG may not be effectively removed by physical separation alone. Therefore, grease traps should be used as preliminary treatment before subsequent biological or other appropriate processes.

Biological Characteristics of Wastewater from Nutrition Service Units

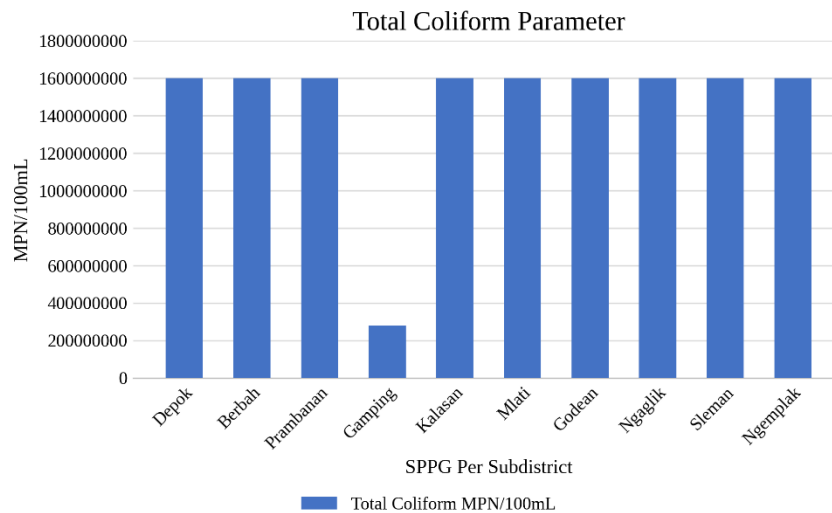


Figure 6. Total Coliform Concentration in Kitchen Wastewater of SPPG by District

Total coliform concentrations exceeded the detection limit at most SPPGs ($>16 \times 10^8$ MPN/100 mL), while Gamping recorded 28×10^7 MPN/100 mL, indicating substantial microbial contamination associated with organic matter. Coliform growth is supported by available organic compounds (Sebayang et al., 2025). Together with elevated TSS, BOD, COD, and oil and grease, these results support integrated physical and biological treatment, as FOG is not always readily removed by physical separation alone. The proposed treatment train includes screening, grease trapping, equalization, anaerobic biofiltration, sedimentation, and filtration. However, the design remains conceptual because flow, hydraulic loading, nutrient concentrations, and pollutant loads were not measured; full-scale design therefore requires further flow- and load-based assessment.

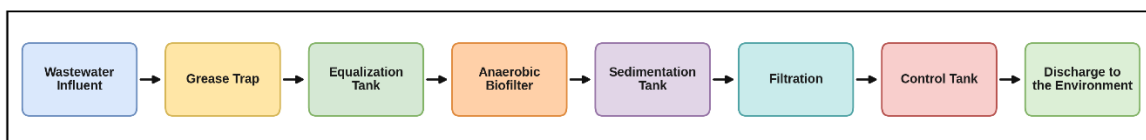


Figure 7. Wastewater Treatment Unit Installation Process

This study characterizes wastewater from 10 SPPGs by linking laboratory parameters with production volume and menu characteristics. The findings indicate that production capacity alone does not determine pollutant concentrations, while fried-food menus may increase oil and grease loading. Because different pollutants require different treatment mechanisms, SPPG wastewater management should use an integrated, sequential treatment approach and be considered from the operational planning stage.

CONCLUSION AND FURTHER RESEARCH

Kitchen wastewater from 10 SPPGs in Sleman Regency showed substantial variation, with TSS of 121–7,340 mg/L, BOD 91–1,445 mg/L, COD 829–8,078 mg/L, oil and grease <0.2–168.4 mg/L, and total coliform exceeding 16×10^8 MPN/100 mL at most locations. Most parameters exceeded the standards under the Minister of Environment and Forestry Regulation No. 11 of 2025, indicating the need for treatment before discharge. Pollutant concentrations were influenced by

production volume and menu composition, particularly fried-food menus. The findings support integrated treatment, including grease traps and biological processes, with capacity based on production loads. However, purposive sampling and a single sampling event limit representation of temporal variation. Further studies should assess repeated sampling, pollutant loads, and treatment performance. These findings support SDG 6, particularly Targets 6.3 and 6.6, through improved wastewater management and protection of water-related ecosystems.

RESEARCH LIMITATIONS

The study is limited by the purposive selection of 10 SPPGs and analysis of only TSS, BOD, COD, FOG, and total coliform, limiting generalizability and assessment of temporal variation and pollutant loads. Descriptive analysis and differences in operational conditions also restrict statistical and causal interpretation. Treatment performance was not evaluated, so treatment effectiveness and required capacity remain to be verified. Future research should use repeated sampling, assess additional parameters and pollutant loads, and evaluate treatment performance under varying production and menu conditions.

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