EVALUATION OF THE WASTEWATER TREATMENT PLANT AT SANITATION UNIT SOEKARNO-HATTA INTERNATIONAL AIRPORT

EVALUASI INSTALASI PENGOLAHAN AIR LIMBAH PADA UNIT SANITASI BANDAR UDARA INTERNASIONAL SOEKARNO-HATTA

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Abstract

The growing demand for rapid transportation has led to a significant rise in air travel, positioning airports as critical hubs of human mobility. This increase in airport users has consequently escalated clean water consumption, primarily due to public lavatory use and airport operational needs. As water usage rises, wastewater generation also increases, necessitating effective treatment through preliminary systems and wastewater treatment plants (WWTPs). This study begins by collecting data on passenger arrivals and departures to project airport population and estimate wastewater generation and distribution for the year 2034. Wastewater sampling was conducted to analyze key parameters, including pH, TSS, BOD, COD, ammonia nitrogen, fats and grease, total coliform, odor, and temperature, using accredited laboratory methods. Field observations, interviews, literature reviews, and questionnaires were used to complement the data. The estimated wastewater generation for 2034 is 259 m³/hour, which remains within the WWTP's design capacity of 516.6 m³/hour. Wastewater distribution is appropriately maintained, with pipeline flow velocities not exceeding 0.3 m³/s. However, the absence of measured flow data limits direct validation of distribution estimates. Evaluation of wastewater quality indicates that preliminary treatment systems, such as grease traps and delaceration units, contribute to reducing pollutant loads prior to WWTP entry. Most quality parameters meet regulatory standards, though total coliform levels from October 2023 to March 2034 exceed the Indonesian Ministry's threshold of 1,000 MPN/100 mL. Nevertheless, the average value of 1,716 MPN/100 mL remains within the allowable limit of 2,000 MPN/100 mL for alternative testing methods.

Keywords: *Airport, Sewerage Systems, Wastewater, Wastewater Treatment, Wastewater Treatment Plant.*

Abstrak

Peningkatan kebutuhan terhadap transportasi yang cepat telah menyebabkan lonjakan signifikan dalam perjalanan udara, menjadikan bandara sebagai pusat mobilitas manusia yang krusial. Kenaikan jumlah pengguna bandara ini berdampak pada peningkatan konsumsi air bersih, terutama akibat penggunaan toilet umum dan kebutuhan operasional bandara. Seiring dengan meningkatnya penggunaan air, volume air limbah yang dihasilkan pun bertambah, sehingga diperlukan sistem pengolahan yang efektif melalui sistem pra-pengolahan dan Instalasi Pengolahan Air Limbah (IPAL). Penelitian ini diawali dengan pengumpulan data kedatangan dan keberangkatan penumpang guna memproyeksikan populasi bandara dan mengestimasi besaran serta distribusi air limbah pada tahun 2034. Pengambilan sampel air limbah dilakukan untuk menganalisis parameter utama, meliputi pH, TSS, BOD, COD, amonia nitrogen, lemak dan minyak, total koliform, bau, dan suhu, dengan metode laboratorium terakreditasi. Observasi lapangan, wawancara, studi literatur, dan kuesioner digunakan sebagai data pendukung. Estimasi timbulan air limbah pada tahun 2034 sebesar 259 m³/jam, masih berada dalam kapasitas desain IPAL sebesar 516,6 m³/jam. Distribusi air limbah dinyatakan berjalan dengan baik, dengan kecepatan aliran pipa tidak melebihi 0,3 m³/detik. Namun demikian, ketiadaan data aliran aktual membatasi validasi

langsung terhadap estimasi distribusi. Evaluasi kualitas air limbah menunjukkan bahwa sistem pra-pengolahan seperti perangkap lemak (grease trap) dan unit delaserasi berperan dalam menurunkan beban pencemar sebelum masuk ke IPAL. Sebagian besar parameter kualitas air limbah telah memenuhi baku mutu yang ditetapkan, meskipun kadar total koliform dari Oktober 2023 hingga Maret 2034 melebihi ambang batas Kementerian Indonesia sebesar 1.000 MPN/100 mL. Namun, nilai rata-rata sebesar 1.716 MPN/100 mL masih berada dalam batas maksimum 2.000 MPN/100 mL untuk metode pengujian alternatif.

Kata kunci: Bandara, Sistem Perlimbahan, Air Limbah, Pengolahan Air Limbah, Instalasi Pengolahan Air Limbah.

1. INTRODUCTION

In the present and upcoming time more people are using airplane for a fast transportation method to get around. Soekarno-Hatta International Airport being the busiest airport for domestic and international flights in Indonesia according to Badan Pusat Statistik (BPS). The increasing number of passengers within the Airport also increases the clean water consumption within the Airport. The clean water from the Airport terminals and facilities is mostly purposed for the toilet use and other purpose that supports the Airport operations (Gohary et al., 2022).

The increase in wastewater quantity presents a significant challenge to wastewater management systems, since the infrastructure may not be fully prepared to handle the increased load, potentially leading to environmental consequences (Dutta et al., 2021). The outcome of increasing wastewater in airport locations could exceed the design capacity volume. The wastewater created by these many sources frequently comprises a mix of contaminants, such as aviation fuel residues, cleaning agents, and machine lubricants. This diverse composition endangers the quality of water bodies and their surrounding ecosystems. Increased contaminants in wastewater can reduce the efficiency of treatment operations and contaminate groundwater and surface water (Baxter et al., 2019). After the pandemic, there has been a considerable increase in the quantity amount of wastewater created in numerous industries, notably at airports (Sun et al., 2023).

The background of this final assignment is to undertake an evaluation Soekarno-Hatta International Airport wastewater distribution and treatment. The evaluation is essential for an assessment of the Airport sewerage systems wastewater distribution and wastewater treatment plant design capacity to facilitate the present and upcoming time wastewater generation. Wastewater qualities within the sewerage systems and wastewater treatment plant from are also to be evaluated for the determination of wastewater treatment unit efficiency and ensure the effluent water quality meets the ministry and other standards. The operation and maintenance for the sewerage systems and wastewater treatment plant are further evaluated to find other negative factors disrupting the wastewater distribution and treatment.

2. MATERIALS AND METHODS

A. Research Overview

This research has been conducted to determine whether the wastewater quality at Soekarno-Hatta International Airport complies with existing regulations, evaluation of the distribution and treatment systems specification and capacity requirement, evaluation of the distribution and treatment systems operation and maintenance. Primary and secondary data were obtained from direct sampling at the sewerage 2 systems and wastewater treatment plant at the Sanitation Unit to assess the quality and conditions of wastewater distribution and treatment at the Airport. Interviews, field observation and other data gathering approach are conducted with personnel in wastewater distribution and treatment from Sanitation Unit Supervision Team as the head and overseer of the whole wastewater distribution and treatment, Vendor that operates and supervise the wastewater treatment and Vendor for the

operation and supervision of the wastewater distribution. Materials and methods are written clearly, so that it can be understood how to collect data, process and analyze data to achieve the objectives. Information must be written completely enough so that it can be repeated by other researchers, either for comparison or development. If necessary, include the library sources used in the materials and methods used.

B. Research Stages

The stages of this research have designed to form a sequential blueprint for executing the final assignment.

1. Literature Review

The importance of a literature review as a foundation cannot be overstated, particularly when it comes to conducting research that encompasses theory, criteria for wastewater treatment, and various other aspects. Central to this process is the comprehensive utilization of resources, including journals, materials, applicable regulations, research reports, and other relevant literature. By delving into these resources, researchers could plan to lay the groundwork for planning and discussion. Such a meticulous approach paves the way for the critical phases of drawing conclusions and, ultimately, providing recommendations. well-informed

2. Management of Research Permission

Permission management is crucial in the research process, ensuring the project has the necessary endorsements from relevant authorities. This step goes beyond procedure, emphasizing transparency and the commitment to ethical standards and regulatory compliance. At Sanitation Unit PT. Angkasa Pura II, the required permits—including research ethics, subject approval sheets, and statements of willingness to comply with research regulations—reflect this dedication to integrity and accountability. Each document plays a vital role in ensuring the research is conducted responsibly, ethically, and according to established guidelines.

3. Data Gathering and Evaluation

1. Data concerning the distribution and treatment of wastewater within the Sanitation Unit at the Airport has been gathered through direct observation, measurement, and evaluation.
2. Details the wastewater sampling process, which is an essential step in the sewerage systems and wastewater treatment plant evaluation. Sampling points within the Airport are sampled in the early segment of sewerage systems in PCP point that is in front of Terminal 2 wastewater generation are flowed into the system, then the next point of sampling is the end of sewerage system, the sampling of wastewater is also collected within the wastewater treatment plant before the process of aeration, lastly the point of sampling is to be at the outlet unit of the wastewater treatment plant (Figure 1).

Figure 1. Wastewater Sampling Location and its Parameters to be Evaluated

3. Information about the education background, previous training, and others in relation to sewerage systems and wastewater treatment from the relevant respondents through questionnaire if possible and direct interviews.
4. Several supporting data is used from the previous evaluation of Analisis Dampak Lingkungan Hidup (Andal) Rencana Pengembangan Bandar Udara Internasional Soekarno – Hatta

(Pengembangan Terminal 4 Tahap I, Landas Pacu 3 Dan Automatic People Mover System) Di Cengkareng, Kota Tangerang Dan Kabupaten Tangerang, Provinsi Banten Tahun 2017 such as determination of clean water service percentage, minimum, and maximum peaking factor.

5. Wastewater quality standards used in the final assignment are categorized into 2 segments that are ministry standards and other standards used by Inti Surya Laboratory for the method of specification.

4. Result and Discussion

From the gathered data, evaluation of the sewerage systems and wastewater treatment plant at the Sanitation Unit of Soekarno Hatta International Airport in accordance with the applicable specification, capacity and regulations. Operation and maintenance data of sewerage systems and wastewater treatment plant is also to be evaluated to search for existing technical issues troubling the systems.

C. Collection Supporting Data

1. Sewerage Systems and Wastewater Treatment Plant Operation and Maintenance Supporting Data The operation and maintenance of sewerage systems and wastewater treatment plant consists of a number of figures to support the study. In this section data are mostly gathered through field observation in the Soekarno-Hatta International Airport. The condition of equipment and unit in sewerage system and wastewater treatment can be seen in Figure 2.

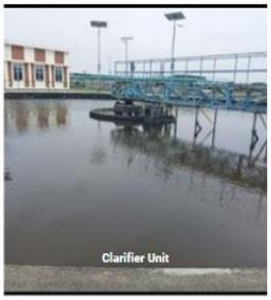

Figure 2. The Condition of Sewerage System and Wastewater Treatment

2. Sewerage Systems and Wastewater Treatment Plant Wastewater Quality Supporting Data

The wastewater quality of sewerage systems and wastewater treatment plant consists inside a table to support the study (Table 1 and Table 2). Wastewater quality data are mostly collected from interviews in the Sanitation Unit. Additional supporting data for the Inti Surya Laboratory water quality analysis within the PCP pumping point and inlet unit from October 2023 until March 2024 is attached below.

Table 1. Wastewater Quality at The PCP Pumping Point With in the Sewerage Systems After the Prior Treatment of Grease Trap and Delaceration Process

Time	Apr-24	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24
Location	Pumping Point	Inlet Unit	Inlet Unit	Inlet Unit	Inlet Unit	Inlet Unit	Inlet Unit
pH (mg/L)	8.35	7.79	6.76	6.86	7.5	6.86	8.35
TSS (mg/L)	187	517	864	472	227	1.142	187
BOD (mg/l)	207	119	95.6	222	152	108	207
COD (mg/l)	696	401	322	743	512	364	696
Grease & Fats (mg/l)	<0.86	<0.86	<0.86	<0.86	1.32	4.3	<0.86
Nitrogen (mg/l)	21.1	82	62.3	88.7	39.1	140	21.1
Total Coliform (MPN/100ml	8.400	17.000	18.000	11.000	9.400	21.000	8.400
Odor	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Temperatures (c)	30	32.6	29.6	28.5	28.9	29	30

Table 2. Wastewater Quality at the Outlet of the Grit and Grease Removable Unit and on the Outlet Unit

Time	Apr-24	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24
Location	Grit Grease Removable Effluent	Outlet Unit	Outlet Unit	Outlet Unit	Outlet Unit	Outlet Unit	Outlet Unit
pH (mg/l)	6.63	7.21	6.75	6.17	7.28	6.95	7.44
TSS (mg/l)	1.290	9	4.67	19.7	8	4.67	17.3
BOD (mg/l)	334	8.93	7.67	17.8	11.3	3.84	11.8
COD (mg/l)	1120	34.8	28.9	62.5	42.7	17.8	44.3
Grease & Fat(mg/l)	4.58	<0.86	<0.86	<0.86	<0.86	<0.86	<0.86
Nitrogen (mg/l)	158	2.09	0.03	1.57	1.28	0.01	3.28
0	25.000	1.700	1.500	2.100	1.600	1.300	2.100
Odor	Yes	No	No	No	No	No	No
Temperatures (c)	31	32	32.2	30	30.7	29	30

3. Sewerage Systems and Wastewater Treatment Plant Design Data

The design for the sewerage systems and wastewater treatment plant comprises various numerical data presented in a table, which serves to support the study comprehensively. This detailed design

information is meticulously gathered from the "Design of Wastewater Treatment Unit Systems at The Sanitation Unit Wastewater Treatment Plant" book. The table includes essential parameters and specifications critical to the understanding and implementation of effective wastewater management systems. By incorporating this structured data, the research ensures a robust foundation for analyzing the efficiency and effectiveness of the proposed designs. Furthermore, the utilization of established design standards and guidelines from the referenced book underscores the reliability and accuracy of the collected data, thereby reinforcing the study's validity and credibility. This comprehensive approach not only aids in the practical application of the designs but also facilitates a deeper understanding of the complexities involved in sewerage systems and wastewater treatment plant operations.

3. RESULT AND DISCUSSION

A. Evaluation of Sanitation Unit Wastewater Treatment Plant Design Capacity

The study employed a detailed demographic analysis method to predict the growth in passenger numbers, analyzing data on departures and arrivals to project future wastewater generation. This involved a comprehensive examination of historical passenger data and growth trends from 2015 to 2034. The projections considered the anticipated increases in both passengers and workers at Soekarno-Hatta International Airport, factoring in variables such as seasonal fluctuations and special events that might impact airport traffic. By applying these projections, the study estimated the future wastewater generation, predicting a total volume that the sewerage system and wastewater treatment plant would need to manage. The projection of wastewater generation in Terminal 1, 2, and 3 can be seen in Figure 3-5.

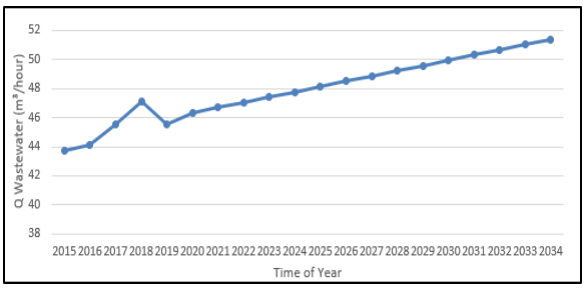

Figure 3. Terminal 1 Wastewater Generation from 2015 to 2034

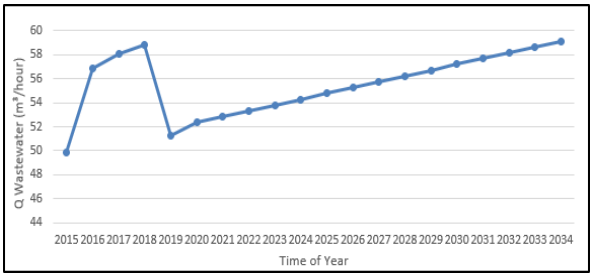

Figure 4. Terminal 2 Wastewater Generation from 2015 to 2034

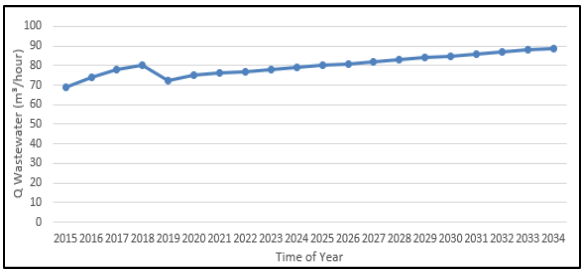

Figure 5. Terminal 3 Wastewater Generation from 2015 to 2034

The planned capacity of the wastewater treatment plant was determined to be 12,400 m³/day, a figure designed to ensure the plant could accommodate the projected increases in wastewater load while maintaining operational efficiency and effectiveness.

B. Evaluation of the Airport Sewerage Systems and Sanitation Unit Wastewater Treatment Plant Wastewater Qualities and Treatment Efficiency.

This sub-chapter consists of the evaluation for the wastewater qualities within the sewerage systems and wastewater treatment plant. Wastewater qualities are analyzed in the Inti Surya Laboratory that is accredited by the Komite Akreditasi Nasional (KAN). The evaluation of wastewater quality involved a thorough analysis of multiple parameters at various points within the sewerage system and the wastewater treatment plant. Initial treatment units, including grease traps and delaceration units, were found to be effective in reducing fats and grease, ensuring these contaminants were minimized before entering the main treatment process. The study monitored key wastewater quality parameters, such as pH, Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), grease, and fats, to ensure compliance with regulatory standards. While most parameters consistently met the required standards, total coliform levels presented occasional challenges (Table 3).

Table 3. Average Wastewater Quality within a 5-Month Period in the Inlet and Outlet

No	Parameter	10/23 to 03/24 (Inlet)	10/23 to 03/24 (Outlet)
1	TSS (mg/l)	569	10
2	BOD (mg/l)	132	10
3	COD (mg/l)	444	38
4	Grease & Fats (mg/l)	0.9	<0.86
5	NH3N (mg/l)	73	1.3
6	Total Coliform (MPN/100ml)	15.066	1.716

The findings indicated that most of these parameters met the regulatory standards set by the Ministry, ensuring that the treated wastewater did not pose a significant risk to the environment. However, an exception was noted in the total coliform levels, which occasionally exceeded the Ministry's standard of 1,000 MPN/100 ml. Despite this, the average total coliform levels over a five-month period were within an alternative standard of 2,000 MPN/100 ml. This discrepancy highlighted the need for continuous monitoring and potential adjustments to the treatment processes to consistently meet all regulatory standards and ensure environmental safety.

C. Evaluation of Airport Sewerage Systems and Sanitation Unit Wastewater Treatment Plant Operation and Maintenance

The study also included an in-depth assessment of the operational and maintenance practices of the sewerage systems and WWTP at Soekarno-Hatta International Airport. This assessment aimed to identify any design flaws or operational inefficiencies that could impact the system's ability to handle the projected wastewater volumes. The analysis of the physical infrastructure, including pipe diameters and materials, confirmed their adequacy in managing the anticipated increase in wastewater load, minimizing the risk of overflows and ensuring smooth operation. However, several maintenance issues were identified that required immediate attention. Key issues included the absence of adequate filtration systems and damaged sludge distribution pumps, which were found to significantly impact the overall efficiency and reliability of the wastewater treatment process. The study provided detailed recommendations to address these problems, such as the installation of smaller waste trapping baskets to prevent blockages, repairing damaged sludge distribution pipes to ensure consistent flow, and replacing old and inefficient pumps to enhance system performance. Implementing these recommendations is crucial for optimizing the sewerage system and WWTP, ensuring that they operate efficiently and comply with all wastewater quality standards. Regular maintenance and timely upgrades will help prevent operational disruptions

and improve the overall sustainability of the wastewater management system at the airport.

4. CONCLUSION

From the research that has been done, the following conclusions are obtained:

1. The evaluation of the Sanitation Unit wastewater treatment plant design capacity indicates that the projected wastewater generation from Airport Terminals and Other Facilities until 2034 is 6.222 m^3/day. This meets the design capacity of the plant, which is about 12.400 m^3/day, as measured at the Pumping Unit of PT. Angkasa Pura 2. This measurement assumes 80% of the clean water distribution from PDAM (15.500 m^3/day) flows to the wastewater treatment plant, with a minimum velocity of
   0.3 m^3/sec in the sewerage system pipelines. Although the calculated wastewater generation aligns with the treatment plant's design capacity and most wastewater quality parameters at the outlet meet quality standards, there is a lack of measured wastewater generation within the sewerage systems and the treatment plant due to the absence of specific wastewater flow meters. This absence hampers the ability to verify the accuracy of the calculated wastewater flow in real field conditions.
2. The wastewater quality in the sewerage systems varies across facilities. Some have prior treatment like chlorination in lavatory trucks, delaceration, and grease trap systems, while others only use grease traps. The 5- month average values at the outlet unit are: pH 6.9, TSS 10.5 mg/L, BOD5 10.2 mg/L, COD 38.5 mg/L, grease and fats <0.86 mg/L, nitrogen 1.3 mg/L, and odorless. These values meet most requirements except for water temperature (32.2°C in November 2023, possibly due to the dry season) and total coliform (1.716 MPN/100 ml). The high coliform levels are due to a lack of chlorination disinfection at the treatment plant. The wastewater quality is influenced by the design, operation, and maintenance of the systems. While the design capacity is met, the lack of chemical treatment and outdated pumping systems in the sludge recirculation unit prevent the wastewater effluent from consistently meeting quality standards.
3. The evaluation of the Airport sewerage systems and wastewater treatment plant operation and maintenance follows standard procedures, including routine preventive and corrective maintenance. Examples include AC checkups using an ampere clamp within the electric panels and replacing old pumping systems. However, field observations revealed issues such as a lack of filtration systems in manholes and pumping points, which could optimize wastewater distribution by handling excess residual waste. Additionally, some sludge drying bed pumps were damaged but quickly replaced with backup systems essential for current wastewater treatment. While the current operation and maintenance are adequate, future adjustments are recommended. These include installing filtration systems in manholes and pumping points and replacing old pumping systems to improve wastewater distribution and treatment.

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