INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 07 Issue 07 July 2024

DOI: 10.47191/ijmra/v7-i07-62, Impact Factor: 8.22

Page No. 3542-3553

Study of SPALD-T Implementation Based on Regulation of the Minister of Public Works and Public Housing Number 04/PRT/M/2017 (Case Study: Surabaya City)

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ABSTRACT: PUPR Ministerial Decree No. 4 of 2017 states that SPALD development is based on 6 criteria including population density, groundwater depth, soil permeability, financing capacity, land slope, and specific areas. If it refers to one of these criteria, Surabaya City is potentially obliged to implement SPALD-T. This research aims to examine how SPALD-T can be implemented in Surabaya City in terms of technical and institutional aspects. The research method was carried out using descriptive analysis with additional mapping using GIS. Descriptive analysis was carried out to describe the condition of Surabaya City. Meanwhile, mapping is used to determine priority locations that can be implemented by the relevant agencies to implement SPALD-T in Surabaya City. Based on the studies that have been carried out, Surabaya City is included in the areas that need to implement SPALD-T in wastewater management efforts. Furthermore, from an institutional perspective, Surabaya City is ready to implement SPALD-T because it has mapped out the tasks between planning, construction, operations and maintenance. The scheme that can be implemented in Surabaya City is SPALD-T for residential areas with a service area of 1 RT 1 WWTP using an anaerobic processing system.

KEYWORDS: Domestic Wastewater, Population Density, SPALD-T, Surabaya, Sustainable Development

I. INTRODUCTION

The centralized domestic wastewater management system (SPALD-T) is a pattern of domestic wastewater disposal (bathing, washing, kitchen and feces) which is channeled out of the house to a wastewater collection channel, then distributed centrally to the domestic wastewater treatment subsystem. The scope of SPALD-T services is divided into 3 which are urban scale, residential scale, and specific regional scale. Based on the Regulation of the Minister of Public Works and Public Housing (Permen PUPR) Number 04/PRT/M/2017 concerning the Implementation of Domestic Wastewater Management Systems, SPALD development is based on 6 criteria, including population density, groundwater depth, soil permeability, financing capacity, land slope, and certain areas. PUPR Ministerial Decree Number 04/PRT/M/2017 states that SPALD-T based domestic wastewater management is applied in an area that has a population density of 150 people/ha. Referring to one of these criteria, large cities in Indonesia have the potential to have an obligation to develop a domestic wastewater management system from SPALD-S to SPALD-T.

One of the cities that implements SPALD-T is Pontianak City. However, the service area has not covered up the entire population. This is proven by research done by Liberda (2021) which discusses benchmarking of the centralized domestic wastewater management system (SPALDT) unit of the SANIMAS IDB program in Pontianak City. Based on this research, the type of SPALD-T implemented is known to be a residential scale SPALD-T with a service area of ±200 people. Furthermore, SPALD-T was also implemented in Palembang City. Similar to that of Pontianak City, the service coverage is only 10% of the population in Palembang City. Based on data from the Central Statistics Agency, the population in Palembang City is around 1.7 million people. This means that only around 170 thousand people are served by SPALD-T. The Sumatra Island region, which has a lower population than Java Island, has already revitalized SPALD-S to become SPALD-T, so there is a need for development steps on Java Island, especially in big cities such as Surabaya City.

The city of Surabaya is experiencing rapid population growth. According to data from the Surabaya City Central Statistics Agency (BPS Kota Surabaya), the population reached 2,887,223 people in 2022, reflecting a growth rate of 0.45%. This surge in population has led to a significant increase in the demand for clean water, as more residents require access to this essential

resource. Consequently, this heightened consumption of clean water has a direct impact on the amount of wastewater generated. As the population continues to rise, the volume of wastewater produced also escalates, posing challenges for the city's wastewater management and environmental sustainability. Effective measures and infrastructure improvements are crucial to addressing the growing need for clean water and the efficient treatment and disposal of wastewater to ensure the health and well-being of Surabaya's residents and the preservation of its environment.

Based on the population value of the City of Surabaya, a study regarding the application of SPALD-T needs to be carried out. The idea for this study emerged because of the challenges that might arise in the process of implementing SPALD-T, including technical location readiness, budget capacity, institutional readiness, human resource readiness, and the role of the community. This study discusses the potential for developing domestic wastewater management in Surabaya City from technical and institutional aspects. The study of the technical aspects aims to review the feasibility and capabilities of Surabaya City in implementing SPALD-T, while the institutional aspects show the direction of development that will be implemented over the next few years. It is hoped that the results of this study will be a basis for planning alternative sanitation development strategies for Surabaya City towards safe and sustainable sanitation.

II. MATERIALS AND METHODS

Study Area

This study takes into account 154 sub-districts within Surabaya City's administrative area. Researchers conducted interviews with community members in sub-districts where centralized domestic wastewater management systems (SPALD-T) are already in place. Additionally, interviews were held with key stakeholders from Bappedalitbang Surabaya City, DLH Surabaya City, and DSDABM Surabaya City to gather comprehensive insights. The study also involved an extensive literature review and the creation of detailed maps, which were undertaken in the Postgraduate Room of the Department of Environmental Engineering at Institut Teknologi Sepuluh Nopember.

Data Collection

The data collected for this study encompasses both primary and secondary sources. Primary data was gathered through indepth interviews with communal IPALD (domestic wastewater management) managers in Surabaya City, as well as representatives from key government agencies involved in the domestic wastewater sector. The targeted agencies include Bappedalitbang Surabaya City, DSDABM Surabaya City, and DLH Surabaya City. These interviews provided valuable insights into the operational challenges and perspectives of those directly managing and regulating wastewater systems.

In addition to the primary data, secondary data was obtained from various government agency reports. These reports include the Surabaya City Profile, the Surabaya City Sanitation Strategy Report, the Surabaya City Regional Medium Term Development Plan Report, and the Surabaya City Environmental Health Risk Assessment Report. These documents offer a comprehensive overview of the city’s demographic, environmental, and developmental context. Furthermore, detailed maps of Surabaya City in shapefile (SHP) format were used to spatially analyze and visualize the data, aiding in the identification of trends and patterns related to wastewater management.

Data Analysis

In this study, the analysis used is descriptive analysis from the results of interviews and literature reviews as a basis for deepening the study of the implementation of SPALD-T in Surabaya City. The interview results are useful for showing a general picture of the field conditions where SPALD-T will or has been operated. In addition, through ArcGIS software, data on population density, depth of groundwater level, and land slope are integrated into the SHP map for Surabaya City to produce a thematic map that describes the classification of SPALD implementation. Determination of alternative processing systems that can be applied for SPALD-T at both urban and residential scales in the city of Surabaya was also carried out based on the results of data analysis. These combined efforts aimed to provide a thorough understanding of the current state of wastewater management in Surabaya. By incorporating diverse perspectives and data sources, the study seeks to inform more effective and sustainable planning for the city's wastewater infrastructure, ultimately contributing to improved environmental health and quality of life for its residents.

III. RESULTS AND DISCUSSION

Technical Aspects in Implementing SPALD-T in the City of Surabaya

This study focuses on three critical technical aspects: population values, groundwater level depth, and land slope. Each of these factors is essential for effective planning of the centralized domestic wastewater management system (SPALD). Population values determine the demand for wastewater management, while the depth of the groundwater level influences the feasibility and

design of the wastewater infrastructure. Additionally, the land slope affects the flow and drainage of wastewater, necessitating careful consideration in the planning process. According to the PUPR Ministerial Decree Number 04/PRT/M/2017, residential areas with a population density of 150 people per hectare are required to implement a centralized domestic wastewater management system (SPALD-T). This decree underscores the importance of these technical aspects in ensuring efficient and sustainable wastewater management in densely populated areas. Figure 1 shows the SPALD classification of 154 sub-districts in Surabaya City based on population density values.

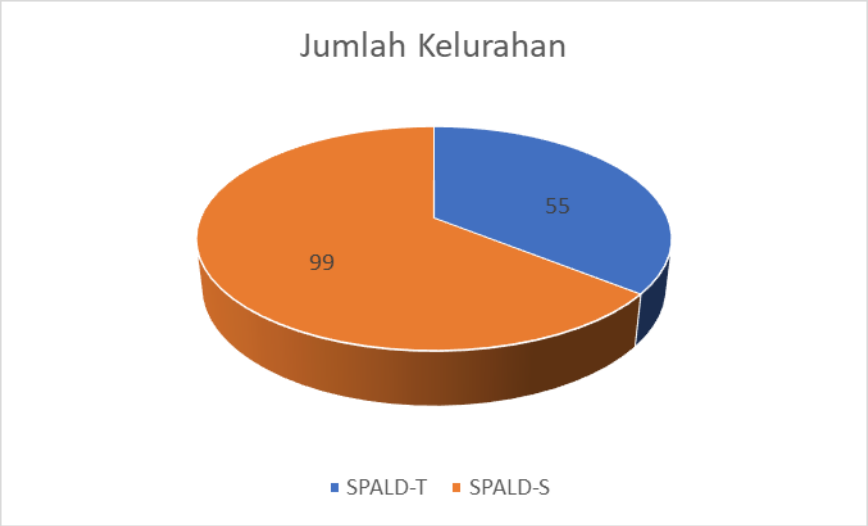

Figure 1: Classification of SPALD implementation in Surabaya City

As many as 55 of the 154 sub-districts in the city of Surabaya have a population density value of more than 150 people/ha. This analysis shows that more than a third of sub-districts in Surabaya City meet the criteria for implementing SPALD-T. The sub-districts in question include the sub-districts of Simolawang, Wonokusumo, Simomulyo Baru, Kapasmadya Baru, Sidodadi, Ampel, Sidotopo, Pengirian, Banyu Urip, Kupang Krajan, Putat Jaya, Wonorejo Tegalsari, Tambakrejo, Wonokromo, Dupak, Jepara, Sidotopo Wetan, North Krembangan, Kemayoran , Tegalsari, Perak Timur, Kedungdoro, Dukuh Setro, Kapasan, Kapasari, Wall Dukuh, Tambaksari, Ngagel Rejo, Pacar Kembang, Rangkah, Gundih, Simokerto, Peneleh, Petemon, Tanah Kali Kedinding, Bendul Merisi, Ploso, Kertajaya, Bubutan, Manukan Kulon, Pacar Keling, Mojo, Pakis, Sawahan, Bulak, Airlangga, Nyamplungan, Gubeng, Jagir, Gading, Kedurus, Tambak Wedi, Keputran, Sawunggaling, and Genteng. To date, not many of the 55 sub-districts have implemented SPALD-T.

Simolawang has the highest population density in Surabaya, with a value of 575.62 people per hectare. This area, characterized by its densely packed residential structures, exemplifies the need for effective domestic wastewater management systems due to the high volume of wastewater generated by its residents. In contrast, Genteng, with a population density of 151.48 people per hectare, represents the lower end of the density spectrum but still falls within the criteria necessitating the implementation of a centralized domestic wastewater management system (SPALD-T). These figures highlight the varying degrees of urgency for wastewater infrastructure across different parts of Surabaya.

According to the data, 36% of Surabaya's areas meet the criteria requiring the adoption of a SPALD-T system. This significant portion of the city underscores the widespread need for advanced wastewater management solutions to handle the increasing urban population and its associated waste. Efficient wastewater management is crucial for maintaining public health, environmental quality, and overall urban sustainability. Despite this clear need, the current implementation levels of SPALD-T systems in Surabaya are notably insufficient, indicating a gap between policy requirements and practical execution.

The Surabaya City Water Resources and Highways Service (DSDABM) reports that the actual implementation of SPALD-T systems in the city is minimal. Currently, these systems cover only one neighborhood (RT), a stark contrast to the extensive need identified. This limited coverage reveals challenges in scaling up wastewater management infrastructure, whether due to financial constraints, logistical issues, or other barriers. Addressing these challenges is imperative for the city to meet its environmental goals and improve living conditions for its residents. The data calls for urgent action to expand the reach of SPALD-T systems, ensuring more comprehensive wastewater management across Surabaya.

According to the 2022 Surabaya City EHRA study, the majority of areas in Surabaya, amounting to 97%, are equipped with private latrines for sanitation purposes. A small fraction, approximately 2%, rely on the toilets of relatives or neighbors, while the

remaining 1% make use of public facilities. This distribution underscores a high prevalence of private sanitation infrastructure across the city, reflecting significant household-level investment in sanitation facilities. Figure 2 illustrates the breakdown of defecation places based on the findings of the study, highlighting the predominant use of private latrines compared to communal or public options. This data is crucial for understanding the local sanitation landscape and can inform targeted interventions aimed at improving access to adequate sanitation facilities, especially in areas where reliance on shared or public toilets persists.

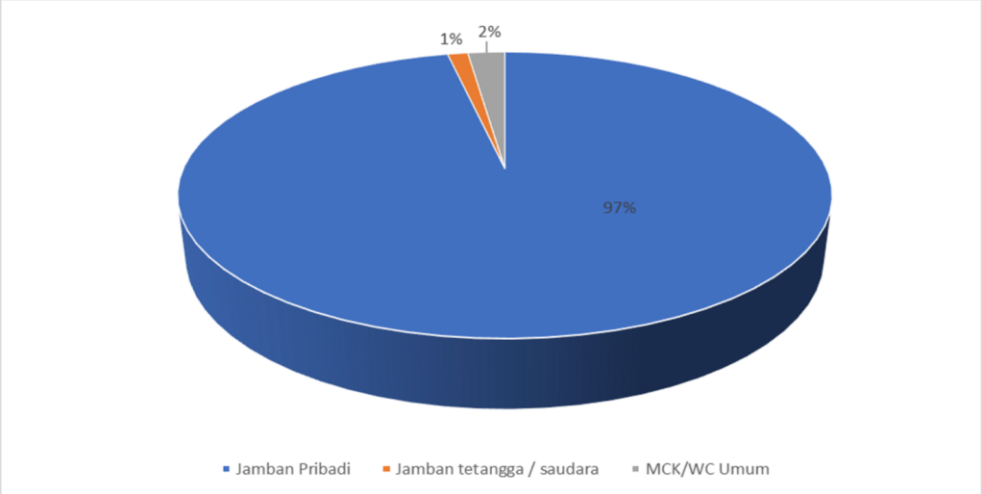

Figure 2: Graph of the percentage of places to defecate

Maintenance practices in Surabaya reveal a notable trend where neither communal IPALDs (Individually Owned, Publicly Managed Septic Tanks) nor individual septic tanks undergo regular draining unless issues like blockages arise. This approach aligns with findings from the 2022 Surabaya City EHRA report, indicating that a significant proportion, around 45%, of septic tanks in the city have never undergone draining. This statistic underscores a potential maintenance gap, where preventive measures such as scheduled tank emptying may be underutilized, possibly due to lack of awareness or financial constraints among residents. The reliance on reactive rather than proactive maintenance strategies in Surabaya underscores a significant area needing improvement in sanitation management practices and infrastructure development. This approach often leads to inefficiencies and increased risks of sanitation system failures, impacting public health and environmental sustainability.

The capacity of the Keputih IPLT to manage fecal sludge efficiently is highlighted by insights from an interview with the Surabaya City Bina Marga Water Resources Service. According to their assessment, the current demand for septic tank suction in Surabaya remains relatively low, indicating that the IPLT can handle significant volumes effectively. To further enhance sanitation standards and promote safe practices, the Surabaya City Government is actively developing regulations governing the suction of fecal sludge at both individual and communal levels. This regulatory framework aims to streamline operations and ensure sustainable management of sanitation infrastructure across the city. Additionally, plans are underway for constructing a dedicated SPALD channel linking the Keputih flats to the Keputih IPLT by 2024. This initiative, led by the DSDABM Surabaya City, seeks to optimize the IPLT's capacity through improved integration of sanitation channels, thereby bolstering the city's overall sanitation infrastructure and resilience against future challenges.

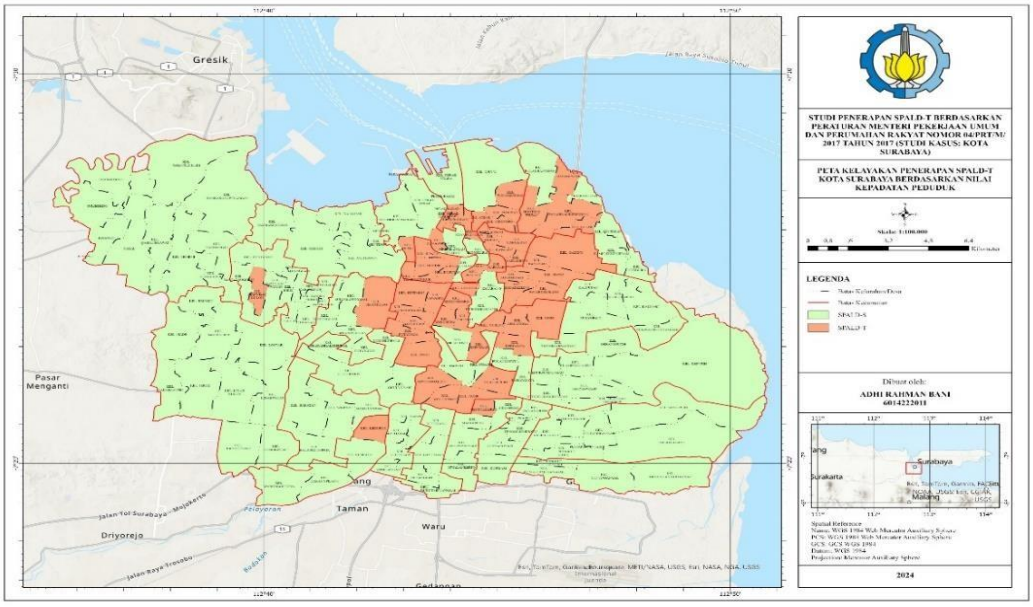

Figure 3: Classification map of SPALD implementation in Surabaya City based on population density values

The PUPR Ministerial Decree Number 04/PRT/M/2017 stipulates that for an area to implement a centralized domestic wastewater management system (SPALD-T), the groundwater level depth must be less than 2 meters. This requirement ensures that the infrastructure for wastewater treatment and disposal is feasible and effective. The decree aims to promote better wastewater management practices in areas where groundwater conditions make traditional methods less viable. By adhering to this standard, regions can enhance their sanitation systems, reduce environmental pollution, and safeguard public health.

Surabaya, with an average groundwater level depth of less than 2 meters, fits this criterion perfectly. This geological characteristic indicates that the city is well-suited for transitioning from a decentralized system (SPALD-S) to a centralized system (SPALD-T). The current groundwater conditions present an opportunity for the city to upgrade its wastewater management infrastructure. Implementing SPALD-T across Surabaya would improve wastewater treatment efficiency and support the city's broader environmental and public health objectives.

The necessity for Surabaya to revitalize its domestic wastewater management system is evident. Transitioning from SPALDS to SPALD-T would address the challenges posed by high population density and shallow groundwater levels. A centralized system can handle larger volumes of wastewater more effectively, reducing the risk of groundwater contamination and ensuring more consistent treatment standards. This transition is critical for the sustainable growth of Surabaya, as it aligns with modern urban infrastructure requirements and environmental sustainability goals. A detailed mapping of Surabaya's areas that meet the groundwater level depth criteria for implementing SPALD-T is provided in Figure 3.

The city of Surabaya, situated in the northern coastal region as depicted in Figure 3, is geographically and topographically characterized by lowlands. One significant challenge of lowland areas like Surabaya is the high groundwater level, which poses difficulties for wastewater management. In wastewater distribution systems, elevation plays a crucial role in maintaining continuous flow. Utilizing gravity in domestic wastewater distribution is advantageous as it eliminates the need for pumping, thereby reducing operational costs. However, in lowland areas where groundwater levels are high, pumps are often necessary to facilitate drainage and ensure wastewater reaches treatment facilities like wastewater treatment plants (WWTPs).

Despite their effectiveness in aiding drainage, the use of pumps in lowland areas contributes to higher operational and maintenance expenses compared to gravity-based systems. These costs include electricity for running pumps and regular maintenance to ensure their functionality. As Surabaya progresses in enhancing its sanitation infrastructure, it faces the critical task of weighing the benefits of gravity-fed systems against the operational complexities and expenses linked to pumpdependent drainage in lowland areas. Achieving this balance is essential for fostering sustainable urban planning and effective management of wastewater in the city.

In areas like Surabaya with high groundwater levels, the depth of WWTP is constrained to ensure they remain above the groundwater level to prevent contamination. Groundwater infiltration into WWTP not only reduces their effective capacity but also risks structural instability due to the compromised soil conditions. To mitigate these challenges, construction techniques such as dewatering methods and the use of concrete reservoirs are crucial. Concrete reservoirs provide a protective barrier against

groundwater intrusion, enhancing the durability and longevity of WWTP despite the challenging environmental conditions. However, these advancements in construction techniques come with increased complexity and higher costs, impacting the overall investment required for building and maintaining effective wastewater treatment infrastructure in lowland areas.

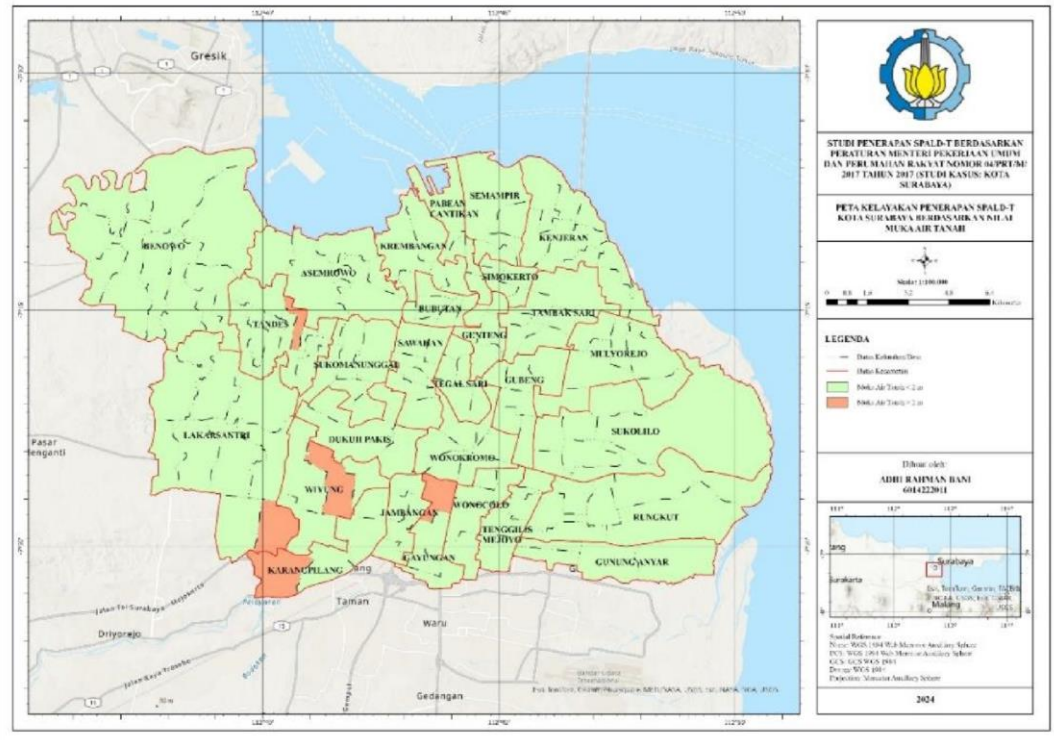

Figure 4: Classification map of SPALD implementation in Surabaya City based on ground water level values

The city of Surabaya is predominantly characterized by its flat topography, with approximately 80% of the area consisting of lowlands with a slope of less than 3%, and the remaining 20% comprising hills with gentle slopes ranging from 5 to 15%. This classification places Surabaya largely within the category of flat plains. According to the PUPR Ministerial Regulation Number 04/PRT/M/2017, regions with a slope value of less than 2% are recommended to implement a centralized domestic wastewater management system (SPALD-T) at the residential scale. Given the flat nature of Surabaya, as evidenced by the mapping results in Figure 4, it is clear that nearly all areas of the city meet this criterion and thus should utilize SPALD-T for effective wastewater management.

The regulation's emphasis on slope value is critical due to its significant impact on wastewater distribution. In flatter areas, wastewater tends to flow less naturally, necessitating more structured and efficient management systems like SPALD-T to ensure proper disposal and treatment. Surabaya's predominantly low slope values make it an ideal candidate for this system. Implementing SPALD-T can mitigate the risks associated with improper wastewater management, such as groundwater contamination and environmental pollution, thereby enhancing the city's overall sanitation and public health standards.

Furthermore, the PUPR Ministerial Decree stipulates that the minimum residential scale service for SPALD-T implementation should cater to at least 50 people. This criterion aligns well with Surabaya's residential patterns, where community units, or RT (Rukun Tetangga), typically encompass around this number of residents. Thus, the decree's guidelines facilitate the practical application of SPALD-T across Surabaya, allowing for manageable and scalable wastewater treatment solutions that can be integrated into existing residential structures without significant overhaul or disruption.

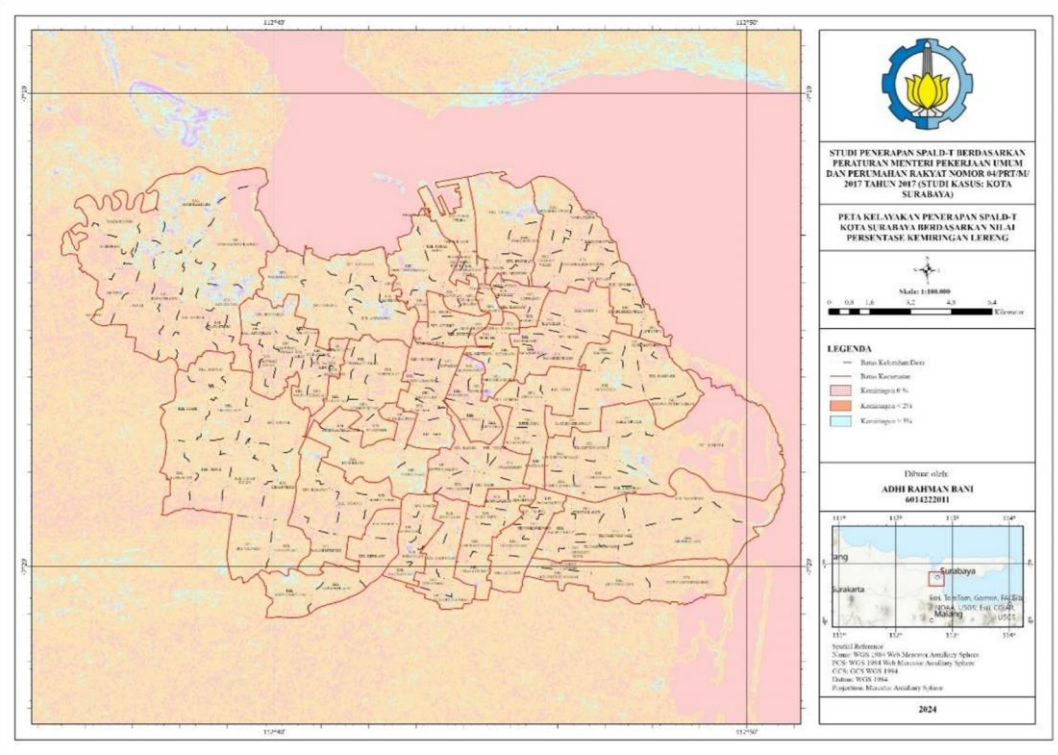

Figure 5. Slope map of Surabaya City

Institutional Aspects in Implementing SPALD-T in Surabaya City

In Surabaya, the management of domestic wastewater is a collaborative effort involving multiple essential agencies and institutions. The Regional Development Planning, Research, and Development Agency (Bappedalitbang) of Surabaya City are integral to this process, specializing in strategic planning and research aimed at bolstering sustainable urban development. Their scope in the implementation of SPALD-T is particularly in wastewater management infrastructure. Their role includes conducting critical studies and offering data-driven insights that shape policy decisions and guide the implementation of infrastructure projects to enhance sanitation services across the city.

The Environmental Service (DLH) of Surabaya City holds a critical mandate in managing environmental protection within the city, specifically overseeing the regulation and monitoring of wastewater treatment and disposal. Their responsibilities encompass enforcing stringent environmental regulations and standards, aiming to protect public health and safeguard the environment from potential pollutants associated with wastewater. DLH plays a pivotal role in ensuring that wastewater treatment processes meet established guidelines, thereby minimizing the impact of pollutants on Surabaya's ecosystems and water resources. Through their regulatory efforts and monitoring initiatives, DLH contributes significantly to maintaining a sustainable and healthy environment for Surabaya's residents and ecosystems alike.

The Water Resources and Highways Service (DSDABM) of Surabaya City plays a crucial role in the management of the city's water resources and infrastructure. They are responsible for overseeing the planning, construction, and maintenance of drainage systems and wastewater treatment plants (WWTPs). DSDABM's primary objective includes ensuring effective drainage systems to mitigate the risk of flooding during periods of heavy rainfall, which is critical for urban resilience and public safety in Surabaya. Additionally, they manage the flow of wastewater to treatment facilities, facilitating the proper treatment and disposal of sewage to enhance sanitation conditions city-wide. By focusing on these responsibilities, DSDABM contributes significantly to maintaining clean waterways, reducing environmental pollution, and promoting sustainable urban development in Surabaya. Their efforts are essential for managing water resources effectively and ensuring a high standard of living for the city's residents.

Table 1 outlines the specific roles and responsibilities of each agency in the management of domestic wastewater in Surabaya, highlighting their collaborative efforts in addressing the city's sanitation challenges comprehensively. Through coordinated planning, regulatory enforcement, and infrastructure development, these agencies work together to enhance wastewater treatment capacities, promote sustainable practices, and mitigate environmental impacts associated with urban development in Surabaya.

Table 1. The role of government agencies in domestic wastewater management

No	Role	Surabaya City Government	Private Parties	Citizens
1	Planning	Bappedalitbang, BPKAD, DINKES, DSDABM, DPRKPP		
2	Procurement of facilities	DSDABM, DLH, DPRKPP	V	V
3	Management	DSDABM, DLH, DPRKPP	V	V
4	Arrangement and coaching	DSDABM, DLH, DPRKPP		
5	Evaluation and monitoring	DSDABM, DLH, DPRKPP, Bappedalitbang		

In Surabaya, the oversight of domestic wastewater management adheres to the guidelines stipulated in PUPR Ministerial Regulation Number 04/PRT/M/2017. This framework delineates the roles and responsibilities of two primary sectors: regional agencies and the community. Regional agencies, such as the Regional Development Planning, Research, and Development Agency (Bappedalitbang) and the Water Resources and Highways Service (DSDABM), play pivotal roles as planners and providers of wastewater management infrastructure. They are responsible for strategic planning, construction, and maintenance of drainage systems, as well as wastewater treatment plants (WWTPs), ensuring the city's sanitation needs are met comprehensively.

Simultaneously, community involvement plays a crucial role in the operational aspects of domestic wastewater management in Surabaya. Residents actively participate in implementing and maintaining wastewater systems, which significantly contributes to their operational efficiency and long-term sustainability. The emphasis on community empowerment reflects a broader strategy aimed at fostering local ownership and sustainability in Surabaya's sanitation efforts. It also builds a sense of responsibility and accountability among its inhabitants. By engaging the community in these activities, Surabaya not only improves the effectiveness of wastewater management practices but also fosters a sense of empowerment among its residents. This collaborative approach ensures that local perspectives and needs are considered in decision-making processes, leading to more tailored and responsive solutions that enhance public health outcomes and environmental quality across the city.

In Surabaya, the implementation of SPALD-T involves the establishment of Community Self-Help Groups (KSM) to manage communal WWTPs. Each communal WWTP is overseen by a KSM, which operates under the management of the local Rukun Tetangga (RT). The KSM typically consists of a chairman, secretary, and treasurer, forming an organized structure responsible for managing the financial aspects related to WWTP operations. This includes collecting fees from residents, typically ranging from IDR 1,000 to IDR 2,000 per month per household, to cover operational expenses such as clean water supply, electricity, and maintenance of sanitation facilities like public restrooms and communal WWTP.

The financial contributions from residents are crucial for sustaining the functionality and upkeep of communal WWTP. This approach ensures that they operate effectively and meet sanitation standards. These funds are allocated towards essential operational costs, securing the accessibility of sanitation facilities and its functionality for the community. The organizational framework of KSMs, supported by the RT, facilitates efficient management and maintenance of WWTPs, promoting community involvement and ownership in sanitation initiatives.

Surabaya demonstrates strong readiness to transition from SPALD-S to SPALD-T, as indicated by survey findings and institutional preparedness. SPALD-T represents a more inclusive approach, involving extensive community engagement and decentralized management of communal wastewater treatment facilities. This strategic shift highlights Surabaya's proactive stance in sustainable urban development, emphasizing collaboration with local communities and implementing robust management frameworks. By leveraging these partnerships and structured approaches, Surabaya aims to enhance its sanitation infrastructure comprehensively, thereby contributing to improved environmental quality and better living conditions for its residents. This forward-looking strategy not only addresses immediate sanitation needs but also lays the groundwork for long-term sustainability and resilience in urban sanitation management.

Alternative Processing Systems for Implementing SPALD-T in Surabaya City

The primary focus in Surabaya's wastewater treatment planning revolves around selecting the most suitable units for the second processing stage within WWTPs. This stage primarily employs microbial activity to enhance the treatment of domestic wastewater. Key considerations in choosing these units include their processing efficiency, initial procurement costs, ongoing operational expenses, and maintenance requirements. It's essential to thoroughly assess each factor to ensure the technology chosen not only meets regulatory standards but also aligns with Surabaya's infrastructure capabilities and financial resources.

Efficiency in processing is crucial as it directly impacts the effectiveness of wastewater treatment, ensuring that pollutants are adequately removed before discharge. The procurement costs of these treatment units must be balanced against longterm

operational expenses. Other than that, it should also be aligned with maintenance needs to optimize investment and resource allocation. Surabaya's approach to unit selection involves evaluating different technologies to determine their suitability for handling varying wastewater volumes and compositions across different parts of the city.

Moreover, ongoing operational costs should also be taken into consideration in the sustainability of wastewater treatment facilities. These costs encompass utilities like electricity and water, as well as labor for maintenance and monitoring activities. By choosing units that are efficient in energy and resource use, Surabaya can minimize operational expenses while maintaining high treatment standards. Additionally, robust maintenance protocols are essential to ensure the longevity and reliability of treatment units, preventing disruptions in wastewater treatment services that could impact public health and environmental quality.

Figure 6: Processing unit flow chart

The alternative considered focuses on the ABR (Anaerobic Baffled Reactor) and anaerobic biofilter systems due to their ability to reduce pollutant levels to meet quality standards, coupled with their minimal land requirements, making them favorable options for further exploration. Anaerobic systems are noted for their cost-effectiveness in terms of operations and maintenance. Sustainability in wastewater treatment can be ensured through the use of chlorination systems with chlorine tablets periodically inserted into the final compartment. This approach maintains the efficiency and effectiveness of the treatment system over time, enhancing its overall sustainability and reliability. Table 2 outlines various considerations regarding the removal efficiency values of the ABR and anaerobic biofilter systems, derived from comprehensive literature reviews based on past studies.

Table 2. Results of research on the pollutant removal efficiency of the processing units

No	Year	Researcher	Results
1	2022	Dorji *et al*.	The use of anaerobic filters with chopped plastic media to treat domestic wastewater in Phuentsholing, Bhutan is able to remove BOD and COD up to 70% and 72% respectively with initial treatment in the form of an upflow anaerobic sludge blanket (UASB).
2	2022	Ma *et al*.	Anaerobic filter units with limonite media used to treat domestic wastewater in Heifei, People's Republic of China are able to reduce the concentrations of COD (C_0 = 240.8 mg/L) and $NH4^+$-N (C_0 = 30 mg/L) respectively to 7 .5 mg/L and 0.35 mg/L.
No	**Year**	**Researcher**	**Results**
3	2021	Saif et al.	In research conducted in Islamabad, Pakistan, the ABR unit used to treat domestic wastewater was able to remove COD concentrations of 2035% of the influent concentration (C_{in} = 104-233 mg/L) in the first three months (start-up), then rose to 47% after going through the start-up period.
4	2019	Cruz et al.	The average TSS, COD, and BOD removal efficiencies obtained from operating anaerobic filters for 15 months to treat domestic wastewater from septic tanks in Campinas, Brazil were 70%, 52%, and 72%, respectively.
5	2019	Schalk et al.	The application of the ABR unit to treat domestic wastewater in Dresden, Germany with an observation period of 16 months showed the highest COD and TSS removal efficiency of 52% and 80% respectively.

6	2019	Yulistyorini et al.	Observations of ABR performance at 23 points included in SPALD-T in Malang Regency showed average BOD, TSS and ammonium removal efficiency of 74%, 66% and 43% respectively. The lowest effluent concentrations of BOD, TSS, and ammonium that can be achieved are 21 mg/L, 30 mg/L, and 0.92 mg/L, respectively.

IV. CONCLUSIONS

Surabaya City qualifies for the implementation of SPALD-T under PUPR Ministerial Regulation Number 04/PRT/M/2017 due to specific criteria met across its sub-districts. Approximately 36% of these sub-districts exhibit high population density (more than 150 people/ha), with groundwater levels below 2 meters and land slopes less than 2%. The Surabaya City Government, through agencies like Surabaya City Bappedalitbang, DSDABM, and DLH, assumes responsibility for domestic wastewater management, with active participation from the private sector and local communities. The recommended approach for
SPALD-T implementation in Surabaya involves a residential-scale model, with each WWTP serving approximately one Rukun Tetangga (RT). Key technologies proposed for SPALD-T include anaerobic baffled reactors (ABR) and anaerobic filters (ABR-AF). These systems are chosen for their effectiveness in reducing pollutant levels and their suitability for the city's environmental conditions. This comprehensive strategy integrates governmental oversight, private sector involvement, and community engagement to ensure efficient and sustainable management of domestic wastewater throughout Surabaya City.

ACKNOWLEDGMENT

We sincerely acknowledge and extend our heartfelt gratitude to Surabaya City Bappedalitbang, DLH, Dinkes, DSDABM, BPKAD, and DRKPP for their invaluable contributions to our study on domestic wastewater management. Their expertise, support, and collaboration have been instrumental in shaping the research and findings of this study. Their dedication to enhancing sanitation practices and ensuring public health in Surabaya has significantly enriched our understanding and efforts in improving wastewater management strategies. We deeply appreciate their commitment and partnership throughout this endeavor, which has been essential in advancing sustainable urban development and environmental stewardship in the city.

REFERENCES

1) Ding, W. and Marchionini, G. 1997 A Study on Video Browsing Strategies. Technical Report. University of Maryland at College Park.
2) Anggriani dan Nadilla. (2022). *Perencanaan dan Modelling Sistem Pengolahan Air limbah Terpusat (SPALD-T) Kota Mataram*. Yogyakarta: UII
3) Anisa, A., & Herumurti, W. (2017). Pengolahan Limbah Domestik Menggunakan Moving Bed Biofilm Reactor (MBBR) dengan Proses Aerobik-Anoksik untuk Menurunkan Konsentrasi Senyawa Organik dan Nitrogen. *Jurnal Teknik ITS*. https://doi.org/10.12962/j23373539.v6i2.25166
4) Apip Supriadi, dkk. (2018). *Analytical Hierarchy Process (AHP): Teknik Penentuan Strategi Daya Saing Kerajinan Bordir*. Yogyakarta: Deepublish.
5) Ayasha, N. L., Handayani, K. N., & Nirawati, M. A. (2024). Resiliensi Permukiman Komunal di Kampung Code Yogyakarta. *ARSITEKTURA*, *22*(1), 1-12.
6) Aziz, M. N., Utomo, B., & Sudarto, S. (2019). Usia Layan Instalasi Pengolahan Air Limbah (Ipal) Semanggi Ditinjau Berdasarkan Kinerja Pada Reaktor Utama. *Jurnal Matriks Teknik Sipil*, *7*(4), 415-422.
7) Bachtiar, I. Y., Wicaksono, A. P., & Yudono, A. R. A. (2021). Tingkat Kerawanan Bencana Banjir Pada DAS Celeng di Kecamatan Imogiri, Kabupaten Bantul, Daerah Istimewa Yogyakarta. *Prosiding Seminar Nasional Teknik Lingkungan Kebumian Satu Bumi III*.
8) Badan Pusat Statistik Kota Surabaya. (2023). *Kota Surabaya Dalam Angka 2023*. Surabaya
9) Cruz, L. M. C., Gomes, B. G. L. A., Tonetti, A. L., & Figueiredo, I. C. S. (2019). Using coconut husks in a full-scale decentralized wastewater treatment system: the influence of an anaerobic filter on maintenance and operational conditions of a sand filter. *Ecological engineering*, *127*, 454-459.
10) Baidillah, I. B., Anna, A. N., & Mediani, A. (2019). Distribusi Kontaminasi Bakteri Colliform berdasarkan Arah Aliran Air Tanah. *Prosiding Seminar Nasional Geografi UMS X 2019*.
11) Ditjen Cipta Karya Kementerian PUPR. (2018). Panduan Perencanaan Teknik Terinci - Sub Sistem Pengolahan Terpusat. *Pedoman Perencanaan Teknik Terinci Sistem Pengelolaan Air Limbah Terpusat (SPALD-T)*, *53*(9), 1689–1699.

12) Dorji, U., Dorji, P., Shon, H., Badeti, U., Dorji, C., Wangmo, C., & Phuntsho, S. (2022). On- site domestic wastewater treatment system using shredded waste plastic bottles as biofilter media: Pilot-scale study on effluent standards in Bhutan. *Chemosphere*, *286*, 131729.
13) Firdaus, A. F., Pribadi, A., Nengse, S., Hakim, A., & Utama, T. T. (2022) Perencanaan Pengembangan Sistem Penyaluran Air Limbah Domestik Terpusat (Spald-T) Kota Surakarta Jalur Utara Dan Tengah. *Jukung (Jurnal Teknik Lingkungan)*, *8*(2).
14) Hahn, M. J., & Figueroa, L. A. (2015). Pilot scale application of anaerobic baffled reactor for biologically enhanced primary treatment of raw municipal wastewater. *Water research*, *87*,494-502.
15) Hamdikatama, B., Nugroho, D., & Saputro, D.T. 2019. Pemetaan Daerah Rawan Banjir di Kota Surakarta Menggunakan Sistem Informasi Geografis. *Indonesian Journal of Networking and Security (IJNS)*, *9*(1), 1-6.
16) Kementerian Pekerjaan Umum dan Perumahan Rakyat. (2017) Peraturan Menteri PUPR No 04/PRT/M/2017 tentang Penyelenggaraan Sistem Pengelolaan Air Limbah Domestik. Jakarta.
17) Kementerian Lingkungan Hidup dan Kehutanan. (2016). Peraturan Menteri LHK No.68 th 2016 tentang Baku Mutu Air Limbah Domestik. Kementerian Lingkungan Hidup Dan Kehutanan, 68, 1–13. http://neo.kemenperin.go.id/files/hukum/19 Permen LHK th 2016 No. P.63 Baku Mutu Air Limbah Domestik.pdf
18) Kurniasari, E., Nurhayati, N., & Akbar, A. A. (2021). Intensitas Curah Hujan dan Fluktuasi Muka Air Tanah di Kawasan Lahan Gambut di Jalan Reformasi Kota Pontianak. *Jurnal Teknik Sipil*, *21*(2), 254-258.
19) Liberda, R., Apriani, I., & Utomo, K. P. (2021). Studi Benchmarking Unit Sistem Pengelolaan Air Limbah Domestik Terpusat (SPALDT) Program SANIMAS IDB di Kota Pontianak. *Jurnal Ilmu Lingkungan*, *19*(2), 465-478.
20) Ma, D., Wang, J., Li, H., Che, J., & Yue, Z. (2022). Simultaneous removal of COD and NH4+- N from domestic sewage by a single-stage up-flow anaerobic biological filter based on Feammox. *Environmental Pollution*, *314*, 120213.
21) Metcalf and Eddy, Inc.. (2003). *Wastewater Engineering: Treatment, Disposal and Reuse (4th Edition)*. New York: McGraw Hill.
22) Ningsih, Dwi Agustiang dan Soedjono, Eddy Setiadi. (2019). *Kajian Penerapan Sistem Pengelolaan Air Limbah Domestik Terpusat (SPALD-T) Di Kecamatan Sukolilo Kota Surabaya*. Surabaya: ITS.
23) Pemerintah Kota Surabaya. (2021). Rencana Pembangunan Jangka Menengah Daerah (RPJMD) Kota Surabaya 20212026. Surabaya.
24) Pemerintah Kota Surabaya. (2022). Strategi Sanitasi Kota (SSK) Kota Surabaya 2022-2026. Surabaya.
25) Pemerintah Kota Pontianak. 2022. Peraturan Wali Kota Pontianak Nomor 15 Tahun 2022 tentang Perubahan Atas Peraturan Wali Kota Nomor 48.2 Tahun 2015 tentang Rencana Induk Pengembangan Sistem Penyediaan Air Minum Kota Pontianak Tahun 2015-2035. Pontianak.
26) Phanwilai, S., Kangwannarakul, N., Noophan, P., Kasahara, T., Terada, A., Munakata-Marr, J., & Figueroa, L. A. (2020). Nitrogen removal efficiencies and microbial communities in full- scale IFAS and MBBR municipal wastewater treatment plants at high COD: N ratio. *Frontiers of Environmental Science & Engineering*, *14*, 1-13.
27) Priambodo, H. D. P., & Herumurti, W. (2021). Perencanaan Pengembangan Sistem Penyaluran Air Limbah Terpusat IPAL Sewon. *Jurnal Teknik ITS*, *9*(2), D196-D202.
28) Rinaldi, R., Biologi, D., Sains, F., Teknologi, D. A. N., & Airlangga, U. (2013). Perencanaan Instalasi Pengolahan Air Limbah Domestik Rumah Susun Penjaringan Sari Rungkut Surabaya.
29) Rohmani, Inatul dan Eddy S. Soedjono. (2016) Kelayakan Tangki Septik/Cubluk di Kelurahan Jambangan dan Karah Kecamatan Jambangan Kota Surabaya. *Jurnal Purifikasi*, *16*(1).
30) Saif, Y., Ali, M., Jones, I. M., & Ahmed, S. (2021). Performance evaluation of a field-scale anaerobic baffled reactor as an economic and sustainable solution for domestic wastewater treatment. *Sustainability*, *13*(18), 10461.
31) Sa'ud, I. (2012). Penggunaan Metode Analytic Hierarchy Process (AHP) untuk Menilai Alternatif Sumur Resapan, Long Storage, dan Tampungan Air sebagai Pengendali Banjir di Surabaya.
32) Schalk, T., Marx, C., Ahnert, M., Krebs, P., & Kühn, V. (2019). Operational experience with a full-scale anaerobic baffled reactor treating municipal wastewater. *Water Environment Research*, *91*(1), 54-68.
33) Silalahi, J. (2010). Analisis kualitas air dan hubungannya dengan keanekaragaman vegetasi akuatik di Perairan Balige Danau Toba. 1–77.
34) Singh, A., Kamble, S. J., Sawant, M., Chakravarthy, Y., Kazmi, A., Aymerich, E., ... & Philip, L. (2018). Technical, hygiene, economic, and life cycle assessment of full-scale moving bed biofilm reactors for wastewater treatment in India. *Environmental Science and Pollution Research*, *25*, 2552-2569.
35) Sugiharto. (2008). *Dasar-Dasar Pengelolaan Air Limbah*. Jakarta: UI-Press.

36) Y. V. Afandi, H. R. Sunoko, and K. Kismartini. (2014). Status Keberlanjutan Sistem Engelolaan Air Limbah Domestik Komunal Berbasis Masyarakat Di Kota Probolinggo. *Jurnal Ilmu Lingkungan*, *11*(2), 100-109.

37) Yulistyorini, A., Camargo-Valero, M. A., Sukarni, S., Suryoputro, N., Mujiyono, M., Santoso, H., & Tri Rahayu, E. (2019). Performance of anaerobic baffled reactor for decentralized wastewater treatment in urban Malang, Indonesia. *Processes*, *7*(4), 184.

38) Zhou, X., Zhang, Y., Li, Z., Sun, P., Hui, X., Fan, X., ... & Ratnaweera, H. (2022). A novel two-stage anoxic/oxic-moving bed biofilm reactor process for biological nitrogen removal in a full-scale municipal WWTP: Performance and bacterial community analysis. *Journal of Water Process Engineering*, *50*, 103224.