JOURNAL LA LIFESCI

VOL. 07, ISSUE 02 (132-141), 2026
DOI: 10.37899/journallalifesci.v7i2.3144

Installation Performance Evaluation Domestic Wastewater Treatment Plant in Fulfil Minister of Environment and Forestry Regulation No. 11 of 2025

Irfan Syarifandi[1], Natsar Desi[1], Muhammad Chaerul[1], Erniati[1], A. M. Yusuf Harun[1], Mahmud[1]

[1]*Magister Rekayasa Infrastruktur dan Lingkungan Universitas Fajar Makassar, Indonesia*

**Corresponding Author: Irfan Syarifandi*
Email: syarifandhyi@gmail.com

Article Info

Article history:
Received 27 February 2026
Received in revised from 7 April 2026
Accepted 9 May 2026

Keywords:
Wastewater Domestic
Wastewater Treatment Plant
Efficiency Elimination
Standard Quality
Performance Processing

Abstract

Wastewater management domestic is aspect crucial in control pollution environment. especially in developing areas like Merauke Regency. Research This aim evaluate performance Installation Domestic Wastewater Treatment Plant (WWTP) in Housing District Ulilin in fulfil standard quality Minister of Environment and Forestry Regulation No. 11 of 2025. Research method use approach quantitative descriptive – evaluative with design studies case. Taking sample carried out at the inlet and outlet of the IPAL during September–October 2025 using grab sampling method. with Analysis of TSS, pH, BOD_5, COD, oil and fat, NH_3-N, and total coliform parameters based on Standard Methods (APHA, 2017). The results show that characteristics influence majority exceed standard quality. especially in the parameters BOD_5 (33.4 mg/L), COD (122.5 mg/L), TSS (35.5 mg/L), oil and fat (6.15 mg/L), NH_3-N (13.1 mg/L), and total coliform (3.59×10^3 MPN/100 mL). After processing. all effluent parameters fulfil standard quality with level 100% compliance Efficiency elimination show very good performance. with decline significant on BOD_5 (83.38%), COD (84.04%), TSS (49.30%), and NH_3-N (93.13%). High safety margin to standard quality show system own capacity adequate and resilient reserves to fluctuations burden polluters. In overall. domestic wastewater treatment plant District Ulilin operate effective. stable. and feasible in support protection quality environment in a way sustainabl.

Introduction

Wastewater domestic is one of the source polluter main water bodies in the area urban and residential areas developing (Mito et al., 2026; Zhou et al., 2026; Sun et al., 2026). Improvement amount population and activities domestic impact direct to improvement burden organic, nutrients, and contaminants microbiological entry to environment waters. Without adequate treatment of wastewater domestic can lower quality of water bodies, triggering eutrophication, as well as increase risk disease waterborne diseases (Chen et al., 2021; Dave et al., 2026; Enerijiofi et al., 2026). Therefore that, existence Installation Domestic Wastewater Treatment Plant (WWTP) become component crucial in system sanitation sustainable (Lubis et al., 2026; Laouane et al., 2026; Sari et al., 2026). Globally, wastewater management become part integral to the development agenda sustainable, especially in achievement of Sustainable Development Goals (SDGs) goal 6 related to clean water and sanitation (Maliga et al., 2025; Lamichhane et al., 2025; Tella et al., 2025). The latest study show that effectiveness system processing biology is very important ability reduction of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), which are indicator main pollution organic (Zhang et al., 2022; Rashid, 2025; Nguyen et al., 2025). Optimal performance of the WWTP system does not only determined by design technology, but also by stability operational and capacity

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

adaptation to fluctuations burden polluters (Hu et al., 2026; Abreham Awono & Adam, 2025; Khasnabis et al., 2025).

In Indonesia, control wastewater pollution domestic arranged through regulations standard mandatory quality every manager system processing ensure effluent fulfil standard before thrown away to environment (Soewondo et al., 2025; Hasan & Mizzouri, 2026; Angi et al., 2025). Evaluation level compliance to standard quality become indicator important in evaluate effectiveness system processing as well as protection quality environment (Poursaeid, 2025; Das et al., 2025; Yang et al., 2025). Research latest emphasize that approach evaluation based efficiency allowance and safety margin to standard quality give description more comprehensive about resilience operational installation processing (Li et al., 2023). Water quality parameters such as Total Suspended Solids (TSS), BOD_5, COD, ammonia (NH_3-N), oil and fat, and total coliform are indicator main in evaluate domestic wastewater treatment plant performance. The high the concentration of these parameters at the inlet reflects burden polluter actual that must be reduced through physical, biological, and chemical processes. Research by Wang et al. (2021) shows that efficiency elimination nutrients and materials organic is greatly influenced by conditions operational reactor biological, including time stay hydraulics and balance microorganisms.

In addition, the relationship between BOD and COD often used For evaluate level Biodegradability of wastewater (Savaliya et al., 2026; Arzhangi & Partani, 2025; Javaid et al., 2025). Ratio and correlation both parameters can describe proportion compound organic that can decompose in a way biological compared to with resistant compounds on the biodegradation process (Zhou et al., 2020; Aboutayeb et al., 2025; Pan et al., 2024). Analysis linear regression between BOD_5 and COD becomes approach relevant statistics For understand characteristics organic wastewater as well as need optimization of processing units predecessor. In the context area developing and areas settlement with level urbanization moderate, challenging domestic wastewater treatment plant management covering discharge fluctuations, variations burden pollutants, as well as limitations supervision technical (Arastou et al., 2026; Nurdiyanto et al., 2025; Ma et al., 2025). Recent studies confirm that system processing with capacity adequate reserve (buffer capacity). tend more resilient to surge burden organic (Gao et al., 2022). Therefore that, safety margin analysis between quality effluent and standard quality become important For measure resilience system in term long.

Merauke Regency as a developing region in the region eastern Indonesia faces dynamics growth potential settlements increase wastewater production domestic. Evaluation performance of domestic wastewater treatment plants in this region become important No only For ensure compliance to regulations, but also for support management environment based evidence (evidence-based environmental management). Assessment laboratory data based to inlet and outlet quality provides description empirical about effectiveness of the ongoing processing process. Based on description mentioned, it is necessary study which in a way systematic evaluate domestic wastewater treatment plant performance through analysis characteristics wastewater quality, efficiency pollutant parameter removal, level compliance to standard quality, and connection statistics between organic parameters main. Approach This expected can give contribution scientific in optimization strategy development system wastewater treatment sustainable and adaptive domestic to dynamics burden pollutants at the level local.Purpose from study This is For evaluate performance Installation Domestic Wastewater Treatment (WWTP) in housing District Ulilin, Merauke Regency.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Methods

This research project was conceived in a quantitative paradigm and framed as a descriptive evaluative research based on a case study methodology. This was aimed at more than just describing the nature of wastewater, but to critically evaluate the functionality of the Domestic Wastewater Treatment Plant that serves the Ulilin residential community in the Merauke Regency. Placing the study in the context of a case, the analysis is closely related to the real operational environment of the treatment system and the findings are based on the real field conditions and not the controlled or simulated environment. The study was carried out between September and October 2025, which is two months of time, deemed enough to identify consistent operational patterns and yet sensitive to short term changes in the nature of the wastewater.

To make it possible to capture the transformation process in the treatment system, two points, which were strategically defined, were sampled, i.e. the inlet and the outlet of the installation. The inlet is the raw wastewater that enters the system and is the best indicator of the actual amount of pollutant produced in the residential area by the domestic activities. The outlet on the other hand represents the last treated effluent released to the environment. With the help of the two points, the study can directly monitor the level to which the system minimises the concentration of pollutants. A grab sampling method was used to collect samples based on the instructions in the Standard Methods of the Examination of Water and Wastewater. The technique was chosen due to the fact that it gives a real-time picture of the quality of wastewater at certain points that is suitable in evaluation of performance under normal operational conditions.

The study analytical emphasis was focused on major physicochemical and microbiological indicators that are known to be common signals of domestic wastewater quality. These were Total Suspended Solids, pH, Biological Oxygen Demand, Chemical Oxygen Demand, oil and grease, ammonia nitrogen and total coliform. All the parameters were studied with the help of accepted laboratory methods so that the results could be reliable and comparable. Gravimetric methods were used to measure Total Suspended Solids, whereas Biological Oxygen Demand was obtained by five day incubation process which is an indication of the biodegradable organic load. The method of chemical Oxygen Demand was done through closed reflux method to capture the biodegradable and non biodegradable organic matter. The concentration of ammonia was determined by spectrophotometric analysis and the microbiological quality was evaluated by the use of the Most Probable Number method of total coliform. The protocols of all analytical procedures were based on the procedures described in APHA and were backed up by standard references in the wastewater engineering, which provided methodological rigor during the laboratory phase.

The results of the laboratory analysis were subjected to a systematic descriptive analysis. The initial step was to come up with an average concentration of each parameter in the inlet and outlet to have a considerable background on the conditions of the system input and output. Based on this, the performance of the treatment was evaluated with the help of the calculation of the removal efficiency in the form of a percentage difference between the inlet and outlet concentrations. This measure is an immediate measure of how effective the system is in reducing the loads of pollutants under the various parameters. Meanwhile, the analysis was not confined to the effectiveness but covered adherence to regulatory standards. The quality of the effluent was compared in an organized manner with the limits provided in the Minister of Environment and Forestry Regulation No. 11 of 2025, which made it possible to base the assessment on the relevance of the policy.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Results and Discussion

Characteristics of Wastewater at the Inlet of the Wastewater Treatment Plant System

Analysis results wastewater characteristics domestic at the inlet of the residential wastewater treatment system District Ironwood during period The September-October 2025 research is presented in Table 1 below :

Table 1 Characteristics Wastewater Quality Domestic Inlet of Residential Wastewater Treatment Plant District Ulilin

Parameter	Unit	September 2025	October 2025	Average	Quality standards*	Compliance Status
TSS	mg/L	36	35	35.5	30	**EXCEED**
pH	-	6.5	5.8	6.15	6 - 9	**FULFIL**
BOD_5	mg/L	33.7	33.2	33.4	30	**EXCEED**
COD	mg/L	122.7	122.4	122.5	100	**EXCEED**
Oil & Fat	mg/L	5.5	6.8	6.15	5	**EXCEED**
NH_3-N	mg/L	12.8	13.4	13.1	10	**EXCEED**
Total Coliform	MPN/100mL	3,669	3.52	3.59	3	**EXCEED**

Source : Analysis results laboratory, 2025

Based on Table 1, the characteristics of wastewater domestic inlet shows worrying conditions with majority of parameters exceed standard quality Minister of Environment and Forestry Regulation No. 11 of 2025. The average TSS parameter of 35.5 mg/L exceeds standard 30 mg/L, indicating height content solids suspended. BOD_5 and COD indicate average values of 33.4 mg/L and 122.5 mg/L, respectively, both exceed standard quality 30 mg/L and 100 mg/L.

Oils and fats exceeded 6.15 mg/L on average standard 5 mg/L, indicating contribution significant waste kitchen. NH_3-N with an average of 13.1 mg/L is very high standard quality 10 mg/L, indicates height organic nitrogen load. The average total coliform was 3.59×10^3 MPN/100 mL exceeding standard 3×10^3 MPN/100 mL, indicating contamination microbiological high. Only the pH parameter with an average of 6.15 meets the requirements. range standard 6-9, although tend acid. The majority of inlet conditions exceed standard quality show the need wastewater treatment system with efficiency tall For reach quality effluent that meets standard.

Characteristics of Wastewater at the Outlet of the Wastewater Treatment Plant System

Evaluation suitability results wastewater treatment with standard quality Minister of Environment and Forestry Regulation No. 11 of 2025 is presented in Table 2:

Table 2. Characteristics Wastewater Quality Domestic Outlet of Residential Wastewater Treatment Plant District Ulilin

Parameter	Unit	Outlet Sept 2025	Outlet Oct 2025	Average	Quality standards	Compliance Status
TSS	mg/L	16	20	18	30	FULFIL
pH	-	7.1	7	7.05	6 to 9	FULFIL
BOD_5	mg/L	4.7	6.4	5.55	30	FULFIL
COD	mg/L	17.2	21.9	19.55	100	FULFIL
Oil & Fat	mg/L	2.2	2.1	2.15	5	FULFIL
NH_3-N	mg/L	0.7	1.1	0.9	10	FULFIL

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Parameter	Unit	Outlet Sept 2025	Outlet Oct 2025	Average	Quality standards	Compliance Status
Total Coliform	MPN/100mL	520	526	523	3,000	FULFIL

Source : Analysis results laboratory, 2025

Based on Table 2 monitoring wastewater quality September and October 2025, all parameters have been fulfil standard established quality. Efficiency system processing looks very significant, especially in the elimination burden organic like COD (down) to 19.55 mg/L) and BOD_5 (down to 5.55 mg/L), both of which far below thresholds of 100 mg/L and 30 mg/L respectively. Overall Compliance Rate : 100% (7 out of 7 parameters meet standard quality). In addition, the NH_3-N parameter shows decline drastic up to 0.9 mg/L with level efficiency reached 93.28%, indicating the nitrification process running optimally. Content total coliform bacteria are also under control with the figure is 523 MPN/100 mL from the maximum limit of 3,000 MPN/100 mL. In a way Overall, the performance of the IPAL is in the very good category, so that the processed water safe For released to environment in accordance regulation.

Research result show that waste water domestic at the inlet of the Domestic Wastewater Treatment Plant Housing area District Ironwood Merauke Regency has distinctive characteristics For area tropical with level urbanization moderate. A BOD_5 concentration of 33.7 mg/L classifies the wastewater as This as wastewater currently based on criteria Metcalf and Eddy (2014) Which sets the wastewater limits moderate at 110 mg/L. However, numbers This has exceeding Environmental Quality Standards of 30 mg/L.

Research result show level 100% compliance with standard quality Minister of Environment and Forestry Regulation No. 11 of 2025, which is very good achievement. Analysis per parameter:

Parameters with High Safety Margin

Based on monitoring results, the WWTP unit is currently operating with an extraordinary level of efficiency, as seen from the outlet value which has a very high safety margin against the Environmental Quality Standard (BML). The BOD_5 parameter only reached 5.55 mg/L from the limit of 30 mg/L (margin 81.5%), while COD was at 19.55 mg/L from the threshold of 100 mg/L (margin 80.5%). In fact, the NH_3-N (Ammonia) parameter showed the most impressive performance with a value of 0.9 mg/L below the maximum limit of 10 mg/L, creating a safety margin of 91%.

This very wide margin is not simply a compliance indicator, but rather an indicator that the wastewater treatment plant (WWTP) system has adequate buffer capacity. This provides operational resilience for the facility in the face of fluctuating pollutant loads and the potential for unexpected operational disruptions. In other words, the system is able to maintain environmentally safe effluent quality even when there are sudden spikes in wastewater discharge or concentration from the source.

Parameters with Medium Safety Margin

Different with organic parameters that have very wide margins, the results analysis show that TSS and oil and fat are in the lower margin zone small. TSS parameters are recorded average value of 18 mg/L compared with a maximum limit of 30 mg/L, which means only have a margin of safety by 40%. Meanwhile that, the Oil & Fat parameter is at 2.15 mg/L against threshold of 5 mg/L, with a safety margin by 57%.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Although in a way legality both parameters Still fulfil standard quality, relative margin of safety low This indicates that system own greater vulnerability tall to fluctuations burden. A little just increase solids or spill oil from inlet side can with fast push outlet value approaching or even beyond regulatory limits.

Comparison with International Standards

Quality effluent from this IPAL system No only comply regulations local, but also shows performance superior to meet standard WHO (2018) international for use reuse wastewater domestic. With BOD_5 value of 5.55 mg/L, processed water This has be under threshold of 10 mg/L, so that worthy used For irrigation limited. Likewise with TSS levels of only 18 mg/L (below the limit of 30 mg/L) for disposal to surface water bodies, as well Total Coliform content of 523 MPN/100 mL is satisfactory criteria safe For contact recreation (maximum limit 1,000 MPN/100 mL).

When compared with study previous, results This in line with findings Metcalf and Eddy (2014) Yang stated that system processing optimal biological can reduce burden organic to below 10 mg/L. In addition, the efficiency elimination coliform bacteria in studies This more Good compared to results study Sutanhaji, Suharto and Darmawan (2021) In a similar IPAL unit, where the coliform count is still often fluctuates above 1,000 MPN/ 100 mL. This prove that the disinfection and stabilization units on your system are working with very high efficiency.

Conclusion

Domestic Wastewater Treatment Plant (WWTP) Housing area District Ironwood Merauke Regency shows very effective performance in lower burden pollutants and fulfill standard applicable quality. The characteristics of the wastewater at the inlet show The majority of parameters, including TSS, BOD_5, COD, oil and fat, NH_3-N, and total coliform, exceeded regulatory threshold, which indicates height burden polluter domestic. However Thus, the results monitoring on the outlet shows level 100% compliance with standard quality with efficiency significant removal, especially on organic and nutrient parameters, as well as a high safety margin against regulatory limits. Analysis regression between BOD_5 and COD shows connection positive affirmation that the biodegradation process walk effective, although Still there is indication existence compound non-biodegradable organics that require attention to the processing unit predecessor. In Overall, the IPAL system has capacity stable and resilient operations to variation burden pollutants, so that worthy stated capable protect quality environment recipient in accordance applicable provision.

Acknowledgments

Saying accept love delivered to all over the party that has give support, especially to mentor thesis that has been give directions, input, and motivation during the research process. Appreciation is also given to IPAL managers and operators Work same and help in field data collection. Hopefully results study This can give contribution scientific for development wastewater management domestic as well as beneficial for improvement quality environment in the future come.

References

Aboutayeb, R., Fijahi, S., Hssaini, L., & Azim, K. (2025). Quality assessment of poultry manure compost: focus on organic amendment and bioremediation roles toward sustainable agriculture. Euro-Mediterranean Journal for Environmental Integration, 10(3), 1383-1405. https://doi.org/10.1007/s41207-024-00698-7

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Abreham Awono, Y., & Adam, D. B. (2025). Evaluation of operational challenges and technological performance of wastewater treatment plants in Addis Ababa. Scientific Reports, 15(1), 33099. https://doi.org/10.1038/s41598-025-17945-8

American Public Health Association (APHA). (2017). Standard methods for the examination of water and wastewater (23rd ed.). American Public Health Association, American Water Works Association, & Water Environment Federation.

Angi, J. C. W., Al Mukarramah, N. H., & Maskun, M. (2025). Mitigating water depletion through wastewater management law in Indonesia's textile sector: Evaluating compliance and alignment with national environmental standards. In BIO Web of Conferences (Vol. 155, p. 06017). EDP Sciences. https://doi.org/10.1051/bioconf/202515506017

Arastou, K., Hosseinzadeh, A., Amini, N. G., & Mohabbati, B. (2026). From organic load to nitrate legacy: grey water footprint as a long-term benchmark for treated sugar industry wastewater. Environmental Geochemistry and Health, 48(2), 106. https://doi.org/10.1007/s10653-026-03003-3

Arzhangi, A., & Partani, S. (2025). Development of a biodegradability index for urban rivers using detergent concentration: A case study from Tehran, Iran. American Journal of Environmental Science and Engineering, 9(3), 147-156.

Chen, Y., Fu, B., Zhao, Y., & Wu, Y. (2021). Impacts of domestic wastewater discharge on urban river water quality and ecological health. Journal of Environmental Management, 292, 112776. https://doi.org/10.1016/j.jenvman.2021.112776

Das, S., Khondakar, K. R., Mazumdar, H., Kaushik, A., & Mishra, Y. K. (2025). AI and IoT: Supported sixth generation sensing for water quality assessment to empower sustainable ecosystems. ACS ES&T Water, 5(2), 490-510.

Dave, A., Prasad, P., & Kumari, S. (2026). Recent Updates in Water Contaminants. Environmental Toxicology and Human Health: Current Challenges and Future Perspectives, 113-143. https://doi.org/10.1002/9781394399857.ch6

Enerijiofi, K. E., Musa, S. I., Bhowmik, D., & Nath, S. (2026). Detrimental Influence of Diverse Pollutants on Water Environment and Human Life: Public Health Implications. In Environmental Health and Toxicology (pp. 89-110). CRC Press.

Gao, L., Wang, X., Li, H., & Peng, Y. (2022). Operational resilience of biological wastewater treatment systems under fluctuating organic loading rates. Water Research, 218, 118468. https://doi.org/10.1016/j.watres.2022.118468

Hasan, D. N., & Mizzouri, N. S. (2026). Evaluation of Operation and Maintenance Practices in Existing Domestic Wastewater Treatment Plants in Duhok City. Zanin Journal of Science and Engineering, 2(1), 12-28. https://doi.org/10.64362/zjse.160

Hu, Y., Wei, R., Yu, K., Liu, Z., Zhou, Q., Zhang, H., ... & Qu, S. (2026). Evaluating the environmental benefits and resource loads of municipal wastewater treatment plants in China. Environmental Impact Assessment Review, 119, 108334.

Javaid, R., Ikhlaq, A., Rizvi, O. S., Abid, M., Qi, F., & Qazi, U. Y. (2025). Enhancing biodegradability of landfill leachate by hybrid treatment process: coagulation followed by catalytic ozonation with Z5Å-Fe-Zn for environmental sustainability. Journal of Water Process Engineering, 75, 107938. https://doi.org/10.1016/j.jwpe.2025.107938

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Khasnabis, A., Parthasarathy, C., Rani, A., Kokurde, V. R., & Subbiah, S. (2025). Assessment of the Condition of a Wastewater Treatment Plant. In Wastewater Treatment Plants: Processes, Assessment, Design and Operation (pp. 215-267). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-87461-1_11

Lamichhane, P., Poudyal, B., Paudel, S., Khadka, P., & Kharel, R. (2025). Bridging local initiative and global goals: Role of water treatment plant for localizing sustainable development goal 6, target 6.1. World Water Policy, 11(1), 122-139. https://doi.org/10.1002/wwp2.12239

Laouane, H., El Joumri, L., Halhaly, A., Arid, Y., Labjar, N., & El Hajjaji, S. (2026). Life-Cycle Assessment of Wastewater Treatment: Enhancing Sustainability Through Process Optimization. Sustainability, 18(2), 605. https://doi.org/10.3390/su18020605

Lubis, M. F., Nasution, A. J., Sari, I. V., Dermawan, A. A., & Sihombing, P. M. (2026). Domestic Wastewater Quality Information System Integrated with the Internet of Things. Journal of Applied Informatics and Computing, 10(2), 1505-1512. Lubis, M. F., Nasution, A. J., Sari, I. V., Dermawan, A. A., & Sihombing, P. M. (2026). Domestic Wastewater Quality Information System Integrated with the Internet of Things. Journal of Applied Informatics and Computing, 10(2), 1505-1512. https://doi.org/10.30871/jaic.v10i2.12482

Ma, Y., Liu, Y., Liang, K., Ding, S., Qiao, X., Liu, Q., ... & Wang, H. (2025). Early warning and management of excessive discharge of water pollutants in municipal wastewater treatment plants based on fluctuation coefficients. Environmental Research, 271, 121127.

Maliga, I., Purwono, S., Harini, R., & Soetarto, A. (2025). Critical indicators for determining sustainable domestic wastewater management for the achievement of SDG goal 6. Discover Water, 5(1), 39. https://doi.org/10.1007/s43832-025-00235-9

Metcalf, W. and Eddy, C. (2014) Wastewater Engineering: Treatment and Resource Recovery, Fifth Edition, Wastewater Engineering: Treatment and Resource Recovery, Fifth Edition.

Mito, M. D., Benti, N. E., Green, L., Geleto, S. D., & Asfaw, S. L. (2026). Impact of anthropogenic pollution on lake ecosystem: a review of Koka and Ziway lakes in the Central Rift Valley, Ethiopia. Environmental Science and Pollution Research, 1-23. https://doi.org/10.1007/s11356-025-37244-z

Nguyen, H. D. P., Le, B. N. T., Nguyen, H. N., Nguyen, T. V. T., Duong, T. L. H., Hoang, T. C., ... & Pham, T. P. T. (2025). Demonstration of adapted packed-bed bioreactor for accurate and rapid estimation of biochemical oxygen demand: insights into the influence of microbial community structure and functions. World Journal of Microbiology and Biotechnology, 41(2), 31. https://doi.org/10.1007/s11274-025-04249-2

Nurdiyanto, M., Joko, T., & Raharjo, M. (2025). Technical Management Impact Assessment Wastewater Against Health Problems in Sanitarian Workers at Hospital X With A Life Cycle Analysis (LCA) Approach. Journal of Social Research, 4(6), 1261-1282. https://doi.org/10.55324/josr.v4i6.2574

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Pan, Y., Meng, L., Wu, Y., Zhang, S., Wu, Z., Zhao, C., ... & Huang, C. (2024). Molecular composition limits the reaction kinetics of riverine dissolved organic matter decomposition. Science of The Total Environment, 950, 175454.

Poursaeid, M. (2025). Comprehensive water quality indicators modeling by environmental protection view using multi optimized weighted ensemble machine learnings. Process Safety and Environmental Protection, 193, 696-709. https://doi.org/10.1016/j.psep.2024.11.042

Rashid, C. H. T. (2025). A Systematic Review of the Effects of Aerobic and Anaerobic Biofilter Processes on the Reduction of Biological Oxygen Demand (BOD) in Domestic Wastewater. Journal of Environmental Health, 17(4).

Sari, E. K., Nur, E., & Tirtaweningtias, S. (2026). Effectiveness of Hotel Wastewater Treatment and Economic Benefits of Clean Water from STP-Based Wastewater Treatment Plants. Jurnal Penelitian Pendidikan IPA, 12(2), 375-382. https://doi.org/10.29303/jppipa.v12i2.14025

Savaliya, B. D., Solomon, J., Karale, T., Kumar, G., Paul, T., Kumar, S., ... & Priyadharshini, T. (2026). Biodegradability Assessment of Aquaculture Effluents: A Comprehensive Analysis of BOD and COD Using Multivariate Statistical Techniques. International Journal of Bio-Resource & Stress Management, 17(2). https://doi.org/10.23910/1.2026.6871

Soewondo, P., Fauzi, M., Gumilar, A., Hastuti, E., Darwati, S., & Ebie, Y. (2025). Evaluating Performance Testing for Fabricated Wastewater Treatment Plant in Indonesia. Future Cities and Environment, 11. https://doi.org/10.70917/fce-2025-010

Sun, Y. L., Hu, Y., Zhou, S. Y., Tian, K. M., Wan, Y. Y., Zhao, S., & Zhang, X. S. (2026). Research Progress on Characteristic Analysis, Source Identification, and Advanced Treatment Technologies for Wastewater in Suburban Transitional Zones. Environmental Quality Management, 35(3), e70321. https://doi.org/10.1002/tqem.70321

Sutanhaji, AT, Suharto, B. and Darmawan, AR (2021) " Installation Performance Evaluation Domestic Wastewater Treatment Plant (WWTP) in Incubator "The Mother of Bontang City's Gem Business," Journal Natural Resources and Environment, 8(2). Available at: https://doi.org/10.21776/ub.jsal.2021.008.02.2.

Tella, T. A., Festus, B., Olaoluwa, T. D., & Oladapo, A. S. (2025). Water and wastewater treatment in developed and developing countries: Present experience and future plans. In Smart nanomaterials for environmental applications (pp. 351-385). Elsevier. https://doi.org/10.1016/B978-0-443-21794-4.00030-2

Wang, J., Zhang, Y., & Li, K. (2021). Nutrient and organic matter removal efficiency in small-scale domestic wastewater treatment systems. Environmental Technology & Innovation, 24, 101821. https://doi.org/10.1016/j.eti.2021.101821

Yang, J., Liu, F., Yang, C., Wei, J., Ma, Y., Xu, L., ... & Wang, J. (2025). Application of Donabedian Three-Dimensional Model in Outpatient Care Quality: A Scoping Review. Journal of nursing management, 2025(1), 6893336. https://doi.org/10.1155/jonm/6893336

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Zhang, Q., Hu, J., Lee, D. J., & Chang, Y. (2022). Advances in biological treatment technologies for domestic wastewater: A review. Bioresource Technology, 344, 126215. https://doi.org/10.1016/j.biortech.2021.126215

Zhou, C., Qi, H., Yang, Z., Sun, Y., Wei, X., Niu, G., ... & Jia, L. (2026). Hydrochemical characteristics, source analysis, and health risk assessment of groundwater in the southwest region of Songling District, Daxing'anling, China. Environmental Geochemistry and Health, 48(4), 158. https://doi.org/10.1007/s10653-026-03020-2

Zhou, Y., Li, P., & Chen, Z. (2020). Correlation between BOD and COD in domestic wastewater: Implications for biodegradability assessment. Journal of Water Process Engineering, 38, 101566. https://doi.org/10.1016/j.jwpe.2020.101566

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)