

DESIGN OF THE “SI AKA” DOMESTIC WASTEWATER TREATMENT SYSTEM BASED ON WASTEWATER CHARACTERISTICS AND FLOW RATE

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Abstract

This research sets out to profile the domestic wastewater produced at the study site, quantify the discharge generated by the surrounding community, and develop an appropriate Wastewater Treatment Plant (WWTP), named Si Aka, that fits actual field conditions while meeting the applicable regulatory standards. The assessment covers physical, chemical, and biological parameters that together define the pollution level and the resulting treatment burden. Discharge figures are then used to size the principal WWTP components, namely the sedimentation basin, the aerobic-anaerobic bioreactor, the disinfection chamber, and the sludge-holding unit. Findings show that the proposed WWTP configuration is capable of raising treatment performance and lowering the risk of environmental pollution through suitable engineering measures. The design is put forward as a viable, decentralized option for treating domestic wastewater in residential neighborhoods.

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Keywords:

Aeration; discharge; influent; treatment; wastewater

Article History:

Received: July 28th, 2026

Revised: October 29th, 2026

Accepted: October 30th, 2026

Published: October 31st, 2026

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1. Introduction

Managing domestic wastewater properly is a key part of environmental sustainability, especially in residential neighborhoods where population numbers and everyday activity levels keep rising. Routine household activities — cooking, bathing, laundering, working from home, and running small home-based enterprises — all consume large volumes of water and, in turn, generate wastewater that needs to be handled appropriately [1]. As people seek greater convenience and a better standard of living, clean-water use tends to rise, which drives a parallel increase in the volume of domestic wastewater produced [2]. This wastewater comes from houses, public buildings, offices, and small enterprises, and typically combines greywater from bathing, washing clothes, and kitchen use with blackwater carrying human waste. Because it can carry detergents, soap residue, oils, fats, organic matter, nutrients, and other household chemicals, discharging it without adequate treatment can lead to serious environmental consequences [3].

Domestic wastewater that goes untreated ranks among the leading contributors to water pollution, given that it is produced continuously and in fairly large volumes wherever people live. In Indonesia, domestic wastewater discharge has been linked to over 70% of the pollution found in rivers [4]. Such wastewater can carry organic pollutants, phosphate compounds, detergents, disease-causing microorganisms, and, in some instances, heavy metals traceable to household use. When left untreated, it can also act as a pathway for waterborne illnesses, including diarrhea, cholera, hepatitis A, and various parasitic infections [5]. Elevated levels of biochemical oxygen demand, chemical oxygen demand, and nutrients can deplete dissolved oxygen, trigger eutrophication, and harm aquatic life. In addition, elevated *Escherichia coli* and coliform counts pose a risk to communities that still rely on shallow groundwater for their domestic water supply [6]. Releasing wastewater into open drains can further generate foul odors, standing water, disease-carrying vectors, and blockages caused by accumulated solids, oil, and grease [7].

Given these environmental and public-health risks, domestic wastewater clearly should not be released into the surrounding environment untreated. A treatment facility is needed to bring down pollutant indicators — biochemical oxygen demand, chemical oxygen demand, total suspended solids, oil and grease, nutrients, and pathogenic organisms — before the effluent reaches soil or a receiving water body. Such a system also has to be tailored to the wastewater's characteristics, its flow rate, the pollutant load it carries, site constraints, community needs, and the relevant effluent standards [8]. A communal treatment system that is well designed can raise

environmental quality, safeguard public health, and reduce the long-term threat of contaminating both surface water and groundwater [6].

At the KM 14 site on Jalan Giri Mulyo, RT 25, Karang Joang, North Balikpapan, rising residential activity and daily water use have led to a growing volume of domestic wastewater from local households. A large share of household greywater and kitchen wastewater is currently released straight into open drains without any prior treatment. This practice has been linked to foul odors, darker drainage water, and a possible risk of contaminating residential wells, especially during the rainy season. These circumstances point to the need for a communal “SI AKA” wastewater treatment facility to safeguard environmental quality, protect community health, and limit long-term pollution in the neighborhood.

This study sets out, first, to characterize domestic wastewater in terms of its physical, chemical, and biological parameters and to establish the wastewater flow rate and pollutant load generated at the study site [3]. Second, it aims to work out the technical design of the communal “SI AKA” wastewater treatment plant so that it matches local conditions, community needs, and the relevant effluent-quality standards [8]. Third, the study seeks to estimate the main construction and operating costs, covering treatment units, equipment, consumable materials, and recurring monthly expenses, in order to gauge the technical and economic feasibility of the proposed system [8]. Ultimately, the intended outcome is a workable, cost-effective, and environmentally sound communal wastewater treatment design that can serve as a technical recommendation for the community and the relevant local authorities [6].

2. Method

This research combines a quantitative descriptive approach with an engineering design method. The quantitative component is used to establish the characteristics of the domestic wastewater, work out the flow rates, and estimate the pollutant loads. The engineering design component, in turn, is used to select the appropriate treatment process and determine the capacity of each treatment unit, the equipment needed, and the leakage-monitoring system for the proposed “SI AKA” domestic wastewater treatment plant. Primary data were gathered through field observation, wastewater sampling, interviews, and direct measurement, while secondary data were drawn from relevant literature, government regulations, population records, and household water-consumption figures.

A. Research Location and Period

This research took place at KM 14, RT 25, Jalan Giri Mulyo, in the Karang Joang subdistrict of North Balikpapan, Balikpapan, East Kalimantan. The area is a residential settlement where domestic activity — bathing, washing, cooking, and sanitation — is fairly intensive and generates a steady supply of domestic wastewater.

Sitting on hilly terrain with an irregular housing layout, the area typically channels domestic wastewater through individual drainage lines, with some of it flowing straight into open drains without adequate treatment. Such conditions raise the risk of contaminating soil, surface water, and groundwater. This site was therefore chosen to assess wastewater characteristics and to develop a communal treatment system suited to the local environmental and community setting.

B. Research Flow Diagram

The research proceeded through several structured stages. It began with a literature review to gather relevant theory, wastewater-quality standards, technical design criteria, and applicable regulations. Field observation was then carried out to identify the research location, covering existing sanitation conditions, wastewater discharge points, drainage patterns, and possible sites for the treatment plant.

Primary and secondary data were then collected and used to analyze wastewater characteristics and calculate the domestic wastewater flow rate. These analyses formed the basis for designing the “SI AKA” wastewater treatment system and its leakage-detection sensor. The resulting design was assessed for treatment effectiveness, technical feasibility, operational requirements, and estimated construction cost, after which conclusions and recommendations were drawn up.

C. Research Procedures

The procedure started by gathering baseline information on the study area's existing conditions, including the number of residents and households, daily water-use patterns, sanitation facilities, drainage conditions, and current wastewater-disposal practices. A literature review was also carried out covering domestic wastewater characteristics, flow-rate and pollutant-load calculations, treatment technologies, and applicable wastewater-quality standards.

Primary data came from direct field observation, wastewater sampling, discharge measurement, and interviews with residents. Samples were tested for relevant physical, chemical, and biological parameters — pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), oil and grease, and coliform bacteria. Secondary data covered population figures, clean-water consumption, technical standards, government regulations, and supporting information obtained from local authorities.

Domestic wastewater flow was calculated from household water consumption together with the estimated share of clean water that turns into wastewater. Pollutant loads were then obtained by multiplying this flow rate by the concentration of each pollutant parameter, and the resulting figures were checked against the applicable domestic wastewater-quality standards.

The “SI AKA” treatment plant was designed around the calculated design flow, pollutant load, available site space, desired treatment efficiency, ease of operation, and community requirements. Design work covered selecting the treatment processes, sizing each unit, specifying equipment, setting the hydraulic retention time, and incorporating leakage-monitoring sensors. The finished design was then checked for technical feasibility, expected treatment performance, operational reliability, and estimated construction cost.

3. Result and Discussion

This section sets out the findings on domestic wastewater characterization, flow-rate calculation, pollutant-load estimation, and the technical design of the “SI AKA” treatment system. These findings are used to assess the existing wastewater conditions and to determine a suitable treatment capacity, process configuration, and supporting control system for the study area.

Result

A. Wastewater Characteristics

Domestic detergent wastewater was assessed against physical, chemical, and biological parameters, since these determine the treatment units required, their capacity, aeration demand, chemical dosing, sludge output, and disinfection needs for the “SI AKA” system. The combined characteristics are set out in Table 1.

Table 1. Wastewater Characteristics

Category	Parameter	Typical Value	Main Contaminant Source	Implication for the “SI AKA” WWTP
Physical	Temperature	28–35 °C	Tropical water and warm laundry water	Generally supports biological activity, but excessive temperature may increase foam formation and disturb process stability.
Physical	Turbidity	50–150 NTU	Fine particles, soap residue, and soil	Influences coagulant demand and the effectiveness of clarification and floc formation.
Physical	Total Suspended Solids (TSS)	100–300 mg/L	Food residue, fabric fibres, and laundry soil	Increases the loading on sedimentation units and the quantity of sludge generated.
Physical	Colour	Cloudy to whitish	Detergent surfactants and foam	Indicates the presence of surfactants that may produce excessive foam and reduce aeration efficiency.
Chemical	pH	6.5–8.5; average 7.5	Soap and detergents	Extreme pH conditions may interfere with coagulation, flocculation, and biological activity.
Chemical	Chemical Oxygen Demand (COD)	250–500 mg/L; average 350 mg/L	Surfactants, oils, and detergent chemicals	Indicates organic and poorly biodegradable pollutants that may require physicochemical pretreatment.
Chemical	Biochemical	100–250	Organic residue, oils, and	Determines aeration requirements,

Category	Parameter	Typical Value	Main Contaminant Source	Implication for the “SI AKA” WWTP
	Oxygen Demand (BOD ₅)	mg/L; average 180 mg/L	fats	biological loading, and bioreactor capacity.
Chemical	BOD/COD Ratio	0.3–0.5	Poorly biodegradable detergent compounds	A ratio below approximately 0.4 indicates limited biodegradability and the need for combined chemical and biological treatment.
Chemical	MBAS/Surfactants	5–15 mg/L; average 10 mg/L	Detergents, liquid soap, and shampoo	May inhibit microorganisms, generate foam, and reduce biological-process stability.
Chemical	Oil and Grease	20–50 mg/L; average 30 mg/L	Kitchen wastewater and laundry residue	May form scum and surface films that inhibit oxygen transfer, requiring a grease-trap unit.
Chemical	Ammonia (NH ₃ -N)	5–20 mg/L	Urine and organic-matter degradation	Requires nitrification or other nitrogen-removal processes before discharge.
Chemical	Total Nitrogen	10–30 mg/L	Food waste and urine	Excessive nitrogen may contribute to eutrophication and increase the nutrient-removal requirement.
Chemical	Phosphate (PO ₄ -P)	3–10 mg/L	Phosphate-containing detergents	May cause eutrophication and require chemical precipitation using alum or iron salts.
Biological	Total Coliform	10 ⁵ –10 ⁶ MPN/100 mL	Bathroom wastewater, washing activities, hands, floors, and food materials	Requires effective disinfection to improve effluent microbiological quality.
Biological	Faecal Coliform	10 ⁴ –10 ⁵ MPN/100 mL	Faecal contamination and laundry water	Determines the need for chlorination, ultraviolet treatment, or another disinfection process.
Biological	Pathogenic Microorganisms	Present at moderate levels	Toilets, dirty floors, and animals	Requires a final disinfection unit to minimize public-health risks.
Biological	Mixed Microbial Load	High	Various domestic water-use activities	Influences biomass stability, aeration demand, and biological-treatment performance.
Biological	Algal-Growth Potential	Moderate to high	Nitrogen and phosphate compounds	Indicates a risk of eutrophication and the need for nutrient control before effluent discharge.

As Table 1 shows, the wastewater carries physical, chemical, and biological contaminants that shape the choice and sizing of the treatment units, above all BOD, COD, TSS, nutrients, microorganisms, and the flow rate itself. Given an average flow of 24 m³/day against a peak flow of 72 m³/day, the peak factor works out to 3.0, meaning hydraulic units — the equalization tank, clarifier, and disinfection tank — must be sized to cope with substantial swings in flow. With an influent BOD of 180 mg/L, the system takes in roughly 4.32

kg BOD/day. At an assumed 80% biological removal efficiency, about 3.46 kg BOD/day would be removed, leaving an estimated effluent BOD of 36 mg/L under ideal conditions. Using a biomass yield coefficient of 0.4 kg VSS/kg BOD removed, the biological process should produce around 1.38 kg VSS/day, a figure that has to be factored into the sizing of the clarifier and the sludge-storage tank [1].

B. Wastewater Flow Rate

Flow rate is a core hydraulic parameter for sizing the “SI AKA” treatment plant, since it dictates the required capacity and dimensions of every unit. The resulting flow is shaped by the number of households and occupants, daily water use, the share of water converted into detergent wastewater, and fluctuations tied to household activity.

Table 2. Wastewater Flow Calculation

Parameter	Assumed Value
Number of houses	100 houses
Occupants per house	4 persons
Domestic water consumption	150 L/person·day
Detergent-wastewater fraction	0.4
Peak factor	3

Based on the assumptions used, the service population totals 400 people. At a consumption rate of 150 L/person·day, total domestic water use comes to roughly 60 m³/day. A detergent-wastewater fraction of 0.4 reflects the portion generated by activities such as laundering clothes, bathing, and cleaning household items, while the peak factor of 3 accounts for the surge in wastewater during periods of heavier household activity.

Table 3. Summary of Wastewater Flow Calculation

Step	Calculation Result
Total population	400 persons
Total water consumption	60,000 L/day or 60 m ³ /day
Average detergent wastewater, Q_{avg}	24 m ³ /day
Converted average flow	0.000277778 m ³ /s
Peak wastewater flow, Q_{peak}	72 m ³ /day
Converted peak flow	0.000833333 m ³ /s

The average flow of 24 m³/day underpins the biological-process calculations, reactor sizing, and mass balances, whereas the 72 m³/day peak flow is used to keep channels, screens, clarifiers, and disinfection units from being hydraulically overloaded [2]. With an influent BOD of 180 mg/L, the system takes in about 4.32 kg BOD/day and calls for roughly an 8 m³ aerobic reactor at an eight-hour hydraulic retention time. Assuming 80% BOD removal, the oxygen demand comes to about 4.15 kg/day, while sludge production is estimated at 1.38 kg VSS/day, requiring around 2.07 m³ of storage over a 30-day cycle [3].

Peak flow also governs the sizing of the clarifier and the chlorine contact tank. At a surface overflow rate of 0.8 m³/m²·hour, the clarifier needs a minimum surface area of about 3.75 m² and a diameter close to 2.19 m. For a 30-minute chlorine contact time, the required tank volume comes to roughly 1.5 m³. Basing these units on peak flow helps keep sedimentation and disinfection performance stable when wastewater generation is at its highest [9].

C. Design of the “SI AKA” Wastewater Treatment Plant

SI AKA, short for Smart Infrastructure for Aquatic Quality Automation, is an integrated wastewater treatment system that governs the treatment process through hydraulic, mechanical, electrical, and monitoring components working together. It brings screening, flow equalization, coagulation–flocculation, biological treatment, sedimentation, disinfection, and sludge management into a single coordinated sequence. Sensors and automated controls can track flow rate, pH, dissolved oxygen, turbidity, and chlorine concentration while regulating pumps, mixers, blowers, and chemical-dosing equipment. The design rests on the wastewater characteristics and estimated pollutant loads generated by domestic activity at KM 14, RT 25, Jalan Giri Mulyo, Karang Joang, North Balikpapan.

Table 4. Summary of Wastewater Flow Calculation

Treatment Component	Design Basis	Main Calculation Results
Wastewater flow	100 houses, 4 persons/house, water consumption of 150 L/person·day, wastewater fraction of 0.4, and peak factor of 3	Design population: 400 persons; water consumption: 60 m ³ /day; Qavg: 24 m ³ /day or 0.000277778 m ³ /s; Qpeak: 72 m ³ /day or 0.000833333 m ³ /s
Screening unit	Qpeak = 0.00083333 m ³ /s; design velocity = 0.8 m/s; bar spacing = 10 mm; bar thickness = 6 mm; screen angle = 60°	Theoretical flow area: 0.00104 m ² ; open area: 0.20 m; actual open area: 0.025 m ² ; bar velocity: 0.0333 m/s
Equalization tank	Qavg = 1 m ³ /hour; HRT = 8 hours; effective depth = 3 m	Required volume: 8 m ³ ; approximate dimensions: 2.31 × 1.15 × 3.00 m
Coagulation tank	Detention time = 2 minutes; velocity gradient = 900 s ⁻¹ ; viscosity = 0.001 N·s/m ²	Tank volume: 3 m ³ ; mixing power: 2.43 kW
Flocculation tank	Detention time = 20 minutes; velocity gradient = 60 s ⁻¹ ; viscosity = 0.001 N·s/m ²	Tank volume: 30 m ³ ; mixing power: 0.108 kW
Clarifier	Qpeak = 3 m ³ /hour; surface overflow rate = 0.8 m ³ /m ² ·hour; depth = 2 m	Surface area: 3.75 m ² ; diameter: 2.19 m; volume: 8 m ³ ; HRT: 8 hours
Aerobic bioreactor	BOD influent = 180 mg/L; Qavg = 24 m ³ /day; HRT = 8 hours; BOD removal = 80%; MLSS = 2.5 kg/m ³	BOD load: 4.32 kg/day; reactor volume: 8 m ³ ; BOD removed: 3.456 kg/day; oxygen demand: 4.1472 kg O ₂ /day; F/M ratio: 0.216 day ⁻¹
Anaerobic bioreactor	Qavg = 1 m ³ /hour; HRT = 24 hours; assumed BOD removal = 50%	Reactor volume: 24 m ³ ; estimated BOD removed: 2.16 kg/day
Disinfection tank	Qpeak = 0.05 m ³ /min; chlorine dose = 2 mg/L; contact time = 30 minutes	Volume: 1.5 m ³ ; chlorine requirement: 48 g/day; CT value: 60 mg·min/L; dimensions: 2.0 × 1.0 × 0.75 m
Sludge storage tank	Biomass yield = 0.4 kg VSS/kg BOD removed; sludge concentration = 20 g/L; storage period = 30 days	Biomass production: 1.3824 kg VSS/day; sludge volume: 0.06912 m ³ /day; minimum storage: 2.0736 m ³ ; recommended capacity: 2.5–3.0 m ³

According to the calculations, the plant needs to handle an average flow of 24 m³/day alongside a peak flow of 72 m³/day. The average figure drives the sizing of the biological reactors, the organic loading, oxygen demand, and sludge output, while the peak figure sets the hydraulic dimensions of the screening, clarifier,

and disinfection units [2]. The clarifier needs roughly 3.75 m^2 of surface area and an 8 m^3 operating volume to keep solids separation stable and limit sludge carry-over [10]. The disinfection tank is designed for a CT value of $60 \text{ mg} \cdot \text{min/L}$, and the sludge tank needs at least 2.07 m^3 of effective storage for a 30-day cycle [8].

The aerobic reactor is sized to remove around 3.456 kg BOD/day , calling for roughly $4.1472 \text{ kg O}_2/\text{day}$ to sustain microbial oxidation. Biomass output is put at about $1.3824 \text{ kg VSS/day}$, yielding around 0.06912 m^3 of thickened sludge daily [3]. The screening channel is sized somewhat larger than the strict hydraulic requirement to leave room for installation, manual cleaning, and operational access [11].

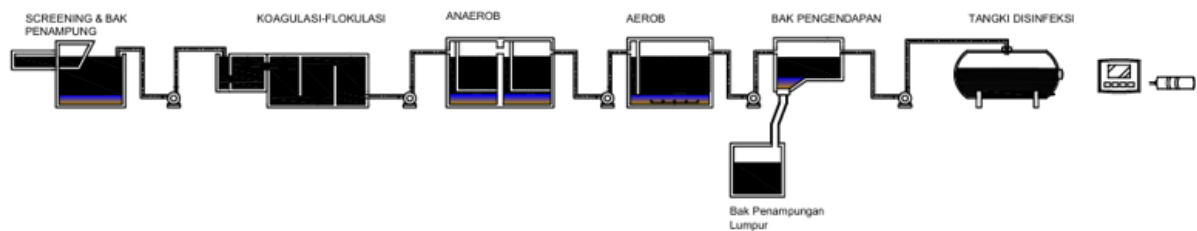


Figure 1. Two-Dimensional Scheme of the “SI AKA” Wastewater Treatment Plant (Author, 2026)

The two-dimensional layout traces the process from the wastewater inlet through to the final effluent outlet. Wastewater first passes through the screening unit, which strips out plastics, fibers, and other coarse debris to protect the pumps and downstream units. It then moves into the equalization tank, which evens out flow and pollutant concentrations ahead of coagulation–flocculation and biological treatment. Biological effluent then flows to the clarifier, where settled sludge is separated from the treated water before disinfection and final discharge [11].

Sludge collected in the clarifier splits into return activated sludge and excess sludge. The former is recycled to the biological reactor to keep the microbial population at the required level, while the latter is sent to the sludge-storage tank. Together, this arrangement forms a continuous treatment pathway spanning physical, chemical, biological, and disinfection stages, supporting stable performance under both average- and peak-flow conditions [11].

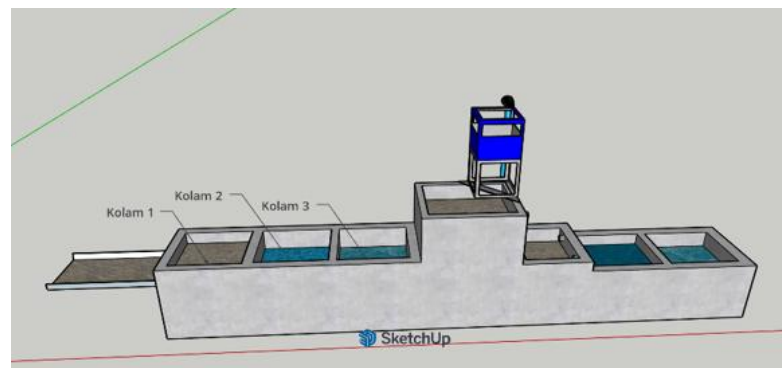


Figure 2. Three-Dimensional Design of the “SI AKA” Wastewater Treatment Plant (Author, 2026)

The three-dimensional layout captures the physical arrangement, relative dimensions, and spatial relationships among the treatment units. It should depict the screening channel, equalization tank, coagulation–flocculation tanks, aerobic and anaerobic reactors, clarifier, disinfection tank, sludge-storage tank, pumps, mixers, blowers, and interconnecting pipework. Equipment should be positioned to allow adequate access for inspection, cleaning, sludge removal, chemical refilling, and equipment replacement, and the final construction design should also allow for sufficient freeboard, maintenance platforms, drainage, ventilation, and electrical protection [8].

Where site elevation allows, the layout should favor gravity flow to cut down on pumping needs and energy use. Automated sensors can be placed at key points to track flow, pH, dissolved oxygen, turbidity, and

residual chlorine, with the control system handling aeration, mixing, pumping, and chemical dosing accordingly. The clarifier and disinfection tank need to hold their calculated hydraulic capacity even during peak flow, while the sludge-storage area should permit sludge to be removed safely and on a set schedule [10].

D. Engineering Control: Leakage Detection Device

A leakage-detection device is fitted to the “SI AKA” disinfection tank to strengthen operational safety and keep the final treatment stage reliable. It tracks abnormal shifts in liquid level, pressure, and moisture around the tank's walls, base, valves, and pipe connections, so that corrective action can be taken early — before leakage leads to equipment damage, chemical exposure, process disruption, or environmental contamination.

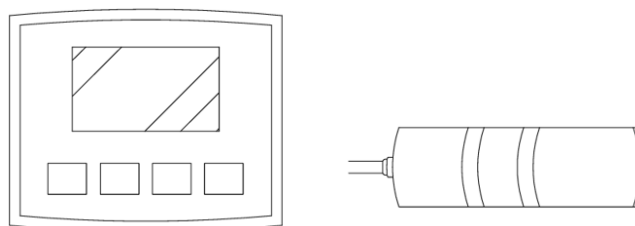


Figure 3. Leakage Detection Device (Author, 2026)

The leakage-detection setup can combine level, pressure, and moisture or conductivity sensors to pick up on different leakage signs, positioned near vulnerable spots such as tank joints, flanges, valves, drainage points, and the tank base. Because the disinfection tank can hold corrosive chlorine compounds, sensor housings and any exposed parts should be made from chemically resistant materials, for example SS316, PVDF, or PTFE-coated components. Using several sensor types together improves detection accuracy and cuts down on false alarms, since level readings can be cross-checked against pressure and moisture data [12].

Sensor readings feed into a PLC, microcontroller, SCADA system, or an Internet-of-Things dashboard for ongoing monitoring and alarm handling. Should an abnormal condition arise, the system can trigger an initial warning, escalate to a critical alarm, halt chemical dosing, shut the inlet valve, or divert the liquid to an emergency holding tank. Records and notifications can also be pushed out through mobile apps, email, SMS, GSM, or LoRa communication channels [3]. Reliability and operator safety should further be supported by secondary containment, backup power, routine sensor calibration, alarm testing, emergency procedures, and appropriate personal protective equipment [9].

Discussion

The key finding here is that the proposed “SI AKA” plant can be designed as an integrated system serving 400 people, with an average wastewater flow of 24 m³/day and a peak flow of 72 m³/day. These hydraulic figures form the basis for sizing the screening channel, equalization tank, biological reactors, clarifier, disinfection tank, and sludge-storage unit. Distinguishing between average and peak flow matters technically, since biological treatment and pollutant mass balances are generally based on average loading, while the physical units still need to withstand maximum hydraulic conditions [2].

The biological-treatment calculations show that an influent load of 4.32 kg BOD/day can be handled by an 8 m³ aerobic reactor, with an estimated BOD removal of 3.456 kg/day. The resulting F/M ratio of 0.216 day⁻¹ points to a reasonable balance between organic substrate and microbial biomass, while the estimated oxygen demand of 4.1472 kg O₂/day informs the choice of aeration system. These results align with earlier work showing that reactor volume, oxygen transfer, biomass concentration, and sludge production are closely linked in activated-sludge processes [3]. The calculated clarifier area of 3.75 m² together with an eight-hour hydraulic retention time may likewise support stable solids separation, though actual performance will still hinge on sludge-settling behavior and operational control [10].

The disinfection and sludge-management results underline how important downstream process control is. A

1.5 m³ disinfection tank dosed with 2 mg/L chlorine over a 30-minute contact time gives an indicative CT value of 60 mg·min/L, which could provide adequate microbial inactivation provided mixing and contact conditions are properly maintained [13]. Meanwhile, the estimated sludge output of 0.06912 m³/day needs at least 2.0736 m³ of effective storage over 30 days, reinforcing the point that sludge handling should be built into the wastewater treatment design rather than treated as an afterthought [8]. That said, the coagulation–flocculation calculation used a flow rate of 1.5 m³/min, which differs substantially from the calculated peak flow of 0.05 m³/min; tank volumes and mixing–power requirements will therefore need to be recalculated before construction [9].

The contribution of this study lies in bringing together hydraulic design, biological treatment, disinfection, sludge management, automation, and leakage detection within one community-scale wastewater treatment concept. The proposed monitoring setup can support real-time tracking of flow, pH, dissolved oxygen, turbidity, chlorine residual, and abnormal tank conditions, letting operators respond more quickly when problems arise. Combining multiple leakage indicators with automated alarms and emergency control actions fits with engineering-control approaches aimed at cutting environmental contamination and occupational exposure [12]. For the community, the design provides a technical framework for improving domestic wastewater management where centralized infrastructure is limited, though pilot-scale testing, field measurement, economic analysis, and verification against applicable effluent standards are still needed before full-scale implementation [11].

4. Conclusion

This study has produced a conceptual design for the Smart Infrastructure for Aquatic Quality Automation (“SI AKA”) wastewater treatment plant, intended for the domestic wastewater generated by roughly 100 households, or about 400 residents, at KM 14, RT 25, Jalan Giri Mulyo, Karang Joang, North Balikpapan. Based on an average flow of 24 m³/day and a peak flow of 72 m³/day, the required capacities for the screening unit, equalization tank, biological reactors, clarifier, disinfection tank, and sludge-storage tank were worked out. The proposed treatment sequence brings together physical, chemical, biological, and disinfection stages to cut down on solids, organic pollutants, and pathogenic microorganisms.

The design also builds in automated monitoring and engineering controls to improve process stability and operational safety. Sensors tracking flow, pH, dissolved oxygen, turbidity, chlorine residual, and leakage can support real-time monitoring and allow for a faster response to abnormal conditions. Overall, the calculated system offers a technical basis for managing wastewater under both normal and peak-flow conditions while supporting controlled sludge handling and final effluent disinfection. That said, field verification, wastewater sampling, pilot-scale testing, economic evaluation, and reconciling the inconsistent design-flow values are still needed before construction and full-scale implementation.

Acknowledgment

The authors wish to thank every member of the research group for their cooperation, dedication, and contribution throughout this study. The authors are also grateful to Arlita Dwi Agustine, the course lecturer, for her guidance, academic direction, and constructive feedback during the research and manuscript-writing process.

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