KOPERNIK
FINDING WHAT WORKS

Enhancing Sustainable Wastewater Treatment for Stilt Houses in Coastal Area

Final report

For: 大和証券グループ Russell Investments

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The Modified Tripikon S is able to treat household wastewater before discharging it into a water body, thereby reducing environmental pollution.

The **coastal community of Batu Ampar currently does not have proper wastewater treatment facilities.** The land's topography makes it hard to use conventional septic tanks, and there aren't any affordable alternatives. As a result, people often dump wastewater into nearby water bodies, which potentially **harms both health and the environment.**

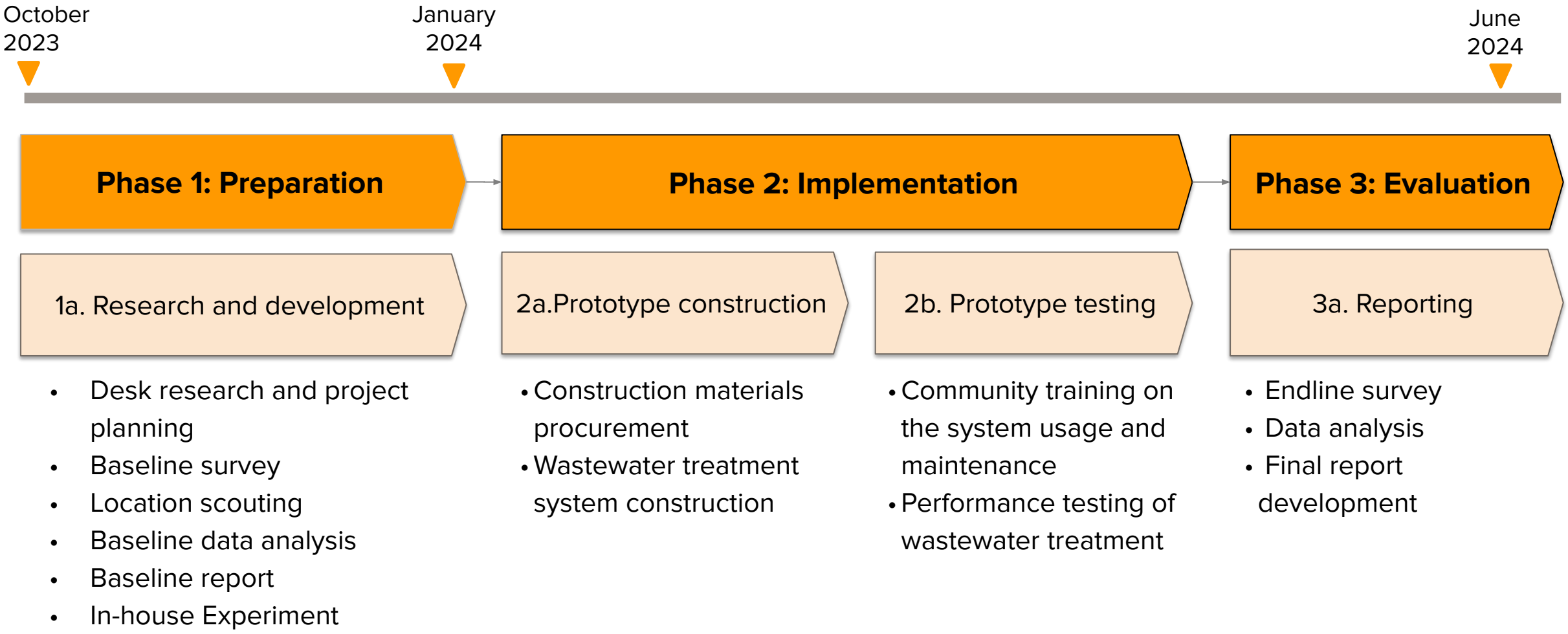
To tackle this issue, we **introduced modified Tripikon S, an alternative wastewater treatment** in Batu Ampar. The Tripikon S underwent two stages of experimentation:

- In-house prototyping at the Kopernik office to finalize the design
- Full-scale construction at the project site to assess the Tripikon performance

The modified Tripikon S system enhances domestic wastewater treatment by reducing biological, physical, and chemical pollutants. Its effectiveness makes it promising solution for coastal areas, helping to mitigate pollution caused by open defecation.

Installed Tripikon S in stilt house

This project was conducted from October 2023 to June 2024 and divided into three main phases: preparation, implementation, and evaluation.



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Sanitation has been a persistent issue in Kubu Raya Regency, West Kalimantan, particularly along the riverbanks and coastal areas. Despite various efforts to improve sanitation, an ideal solution has yet to be found.

Current Sanitation

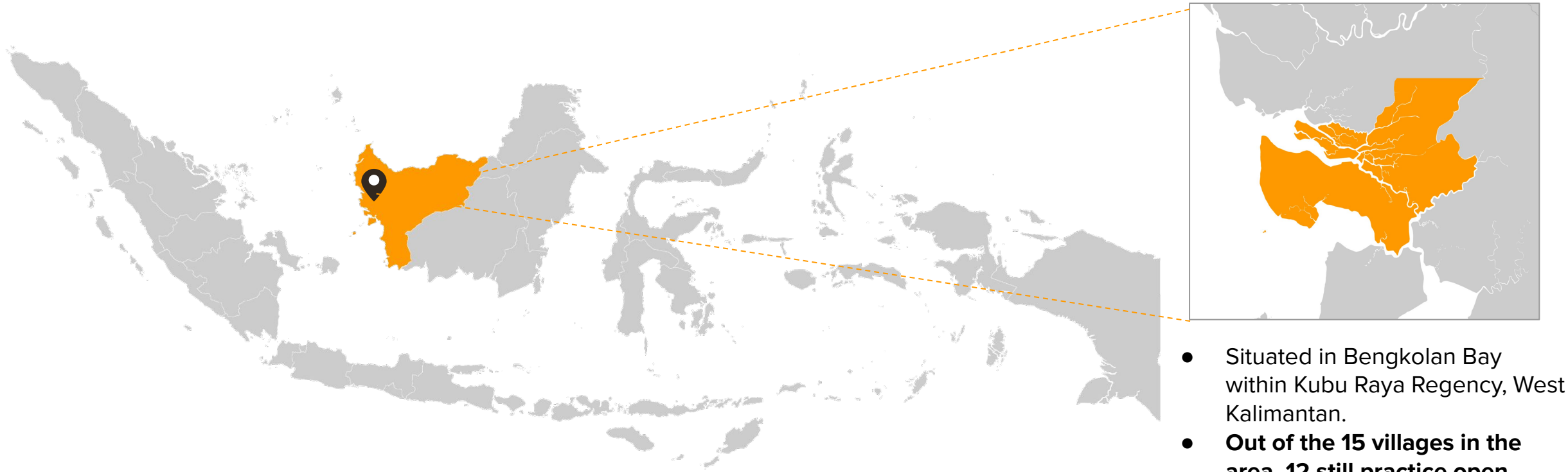
- Currently, 9.07% of residents still practice open defecation in Kubu Raya, and 6.8% of children are stunted, both of which impact residents' quality of life.
- Although there's no data on diarrhea cases, a report from Health Polytechnic in Pontianak (*Poltekkes Pontianak*) shows a link between access to clean water, proper latrine use, and diarrhea incidents.

Stakeholder Efforts

- The government has undertaken several projects to improve sanitation, mainly using conventional septic tanks in standard houses.
- Some Tripikon S units have been installed by external parties in coastal areas of West Kalimantan to enhance sanitation.
- The government is interested in using Tripikon, but since it is not SNI certified, they cannot allocate government funds for its use.

In Batu Ampar Subdistrict, Kubu Raya Regency, a significant number of villages still practice open defecation. This subdistrict is situated in a coastal area with limited connectivity, which complicates efforts to implement effective interventions

Project Location: Batu Ampar Subdistrict



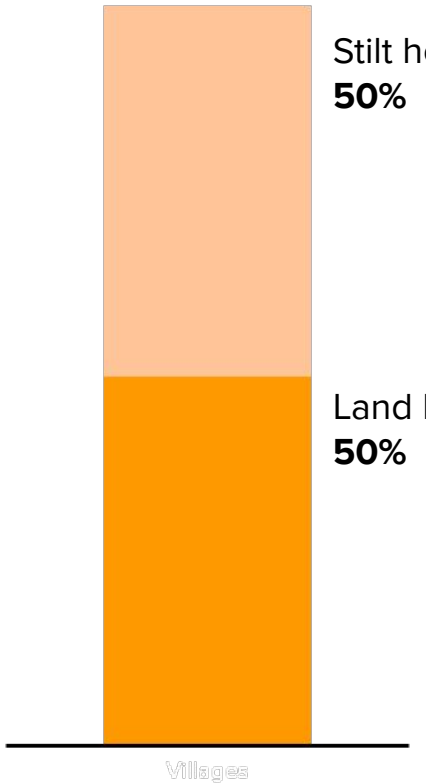
- Situated in Bengkolan Bay within Kubu Raya Regency, West Kalimantan.
- **Out of the 15 villages in the area, 12 still practice open defecation**, highlighting the need for improved sanitation facilities and awareness programs.

Source: Satu Data Kubu Raya, 2022

An assessment by our partner, the Blue Forest Foundation, revealed that 60.3% of residents in Batu Ampar lack proper septic tanks. This issue is largely due to the challenging topography, which makes it difficult to construct septic systems in the stilt houses commonly found in the area

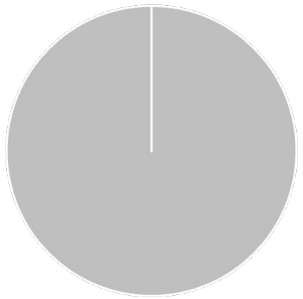
Types of housing in Batu Ampar

in %, total = 512 households (HHs)



Households by Septic Tank Usage Status

in %, total= 216 HHs



Households by Septic Tank Usage Status

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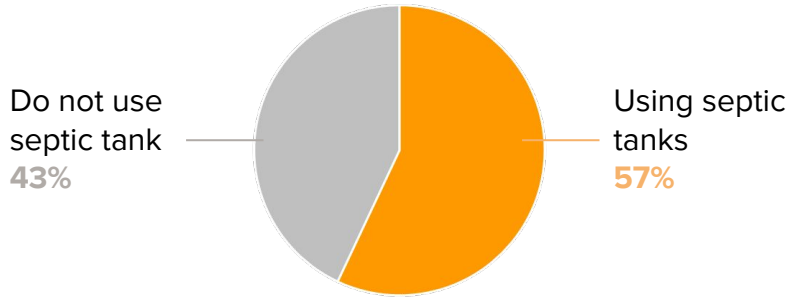

- Traditional septic tanks are unsuitable due to **challenging terrain and tidal forces, make untreated sewage being released into communal water**, which could harm the community's health and the ecosystem.
- Additionally, there are **no commercially available septic tanks specifically designed for these geographic conditions**.

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The absence of wastewater treatment systems in coastal areas requires immediate attention and intervention to safeguard community health and well-being.

PROBLEM

- Growing coastal populations in Indonesia have led to increased pollution, specifically **water pollution from domestic wastewater**.
- **Traditional septic tanks are not suitable** for wastewater treatment in the areas because of **difficult terrain and tidal forces**, causing **untreated sewage to be discharged into communal water bodies**, potentially harming the community's health and ecosystem.
- Furthermore, there are **no commercially available septic tanks** designed for these specific geographical conditions.

SOLUTIONS

- Kopernik **installed the modified Tripikon S**, an **innovative wastewater treatment systems** to reduce water pollution loads in coastal areas with sanitary issues.
- We worked with local university researchers to test how well a modified technology works in a community that currently has no wastewater treatment.

INDICATORS

Output: Tripikon installed and function effectively as shown by wastewater quality

Wastewater Quality Indicator*

a. *Biological Parameters (limit):*
   - Total Coliform

b. *Physical Parameters (limit):*
   - TSS (Total Suspended Solids)

c. *Chemical Parameters (limit):*
   - pH
   - BOD (Biological Oxygen Demand)
   - COD (Chemical Oxygen Demand)
   - Oil & grease
   - Ammonia (NH_3)

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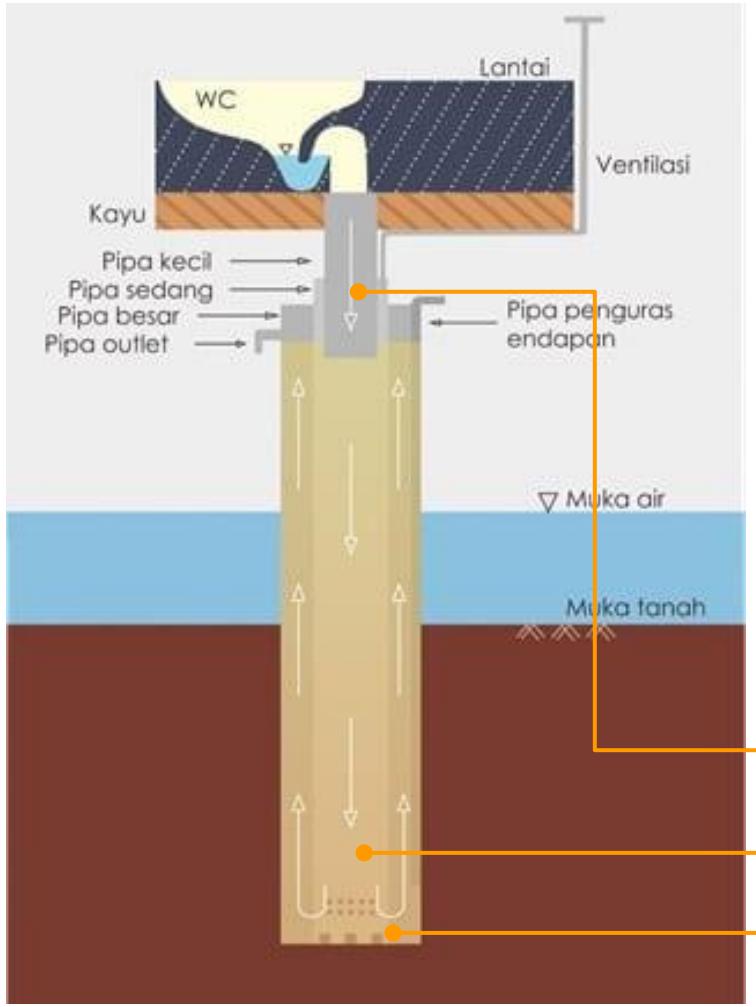
An alternative wastewater treatment, Tripikon S, can be installed in wet areas and has the potential to reduce BOD (Biological Oxygen Demand), pH, and organic substances.



Original design of Tripikon S (one tank)

Overview

- Tripikon-S is a technology invented in 1940 by Prof. Ir. Hardjoso Prodjopangarso from Gadjah Mada University, Indonesia. This technology consist of **three concentric pipes (known as TRIPIKON - TRI PIpa KONsentris Septic)** which able to decrease the **BOD, pH,** and amount of organic substances **(KMnO4)** in blackwater.
- **The estimated cost** to build Tripikon S is IDR **2 - 2.5 million/unit** with **approx. 88L** capacity.
- **Compared to conventional septic tanks**, it is **more appropriate for houses in areas with high water tide or tidal flooding**. Conventional septic tanks cannot be installed due to disruptive soil movements, which cause tanks to leak.
- A regular septic tank should have sufficient volume to provide detention time for the settlement of suspended solids*. The longer the detention time, the better the wastewater will be treated. In the SNI standard, **required detention time is 48-72 hours**, with a wastewater flow rate of **20L per person per day****.

Specification

Pipe #1: Small pipe (inlet) – *Where blackwater from toilets enter.*

Pipe #2: Medium pipe – *Medium pipe functions as flowing line for wastewater, where breakdown of waste occurs.*

Pipe #3: Large pipe – *Where treated water is stored.*

* *Urban Wastewater Management in Indonesia: Key Principles and Issues in Drafting Local Regulations*
** *SNI 2398:2017 : Guidelines for the design of septic tanks with advanced treatment (absorption wells, leach fields, upflow filters, sanitation ponds)*

Due to Tripikon S's lower capacity and short detention time, researchers developed the Tripikon Triple Tanks to enhance both features, targeting a household of four members. However, the Triple Tanks still face odor issues that require further adjustments.

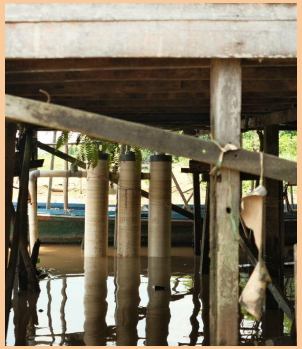
Original design of Tripikon S (one tank)

Specifications:

- Capacity : ± 88L
- Cost: IDR 2-2.5 million/unit
- Short detention (26 hours)

Waste water output:

- The small capacity of Tripikon S causes **fast detention, resulting in short decomposition** and potentially high levels of unintended compounds in the treated wastewater.



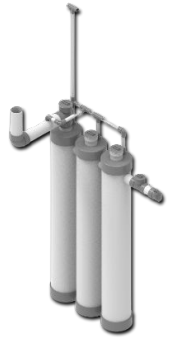
Tripikon (Triple tanks) by Poltekkes Pontianak

Specifications:

- Theoretical Capacity: ± 267L
- Cost: IDR 4-5 million/unit
- Long detention time (80 hours)

Waste water output:

- Despite its **larger capacity for extended decomposition**, this Tripikon requires adjustments due to its low gas outlet level, which allows foul odors to easily disperse into human environments.



Improved Tripikon (Triple tanks) by Kopernik

Desired characteristics:

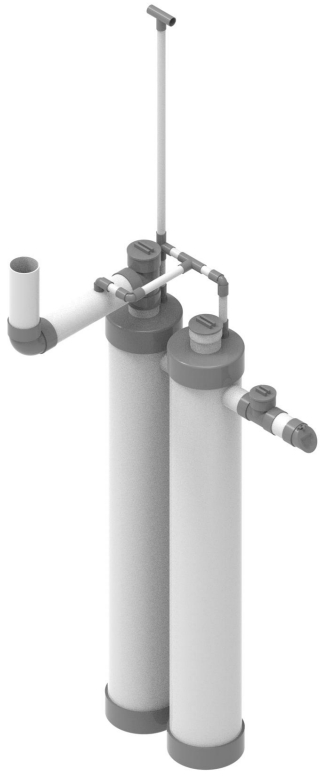
- Theoretical Capacity: >267 L
- Cost: similar to existing Tripikon
- Detention time longer than existing Tripikon

Waste water output:

- **Increase the height of the ventilation pipe outlet** to ensure that the gas **disperses higher in the open air**.
- Add **bio balls to enhance decomposition** by providing more surface area for bacteria to thrive.

We designed two options of Tripikon prototypes with two and three treatment tanks to assess the detention time, affordability, and ease for construction.

Tripikon with Two Treatment Tanks



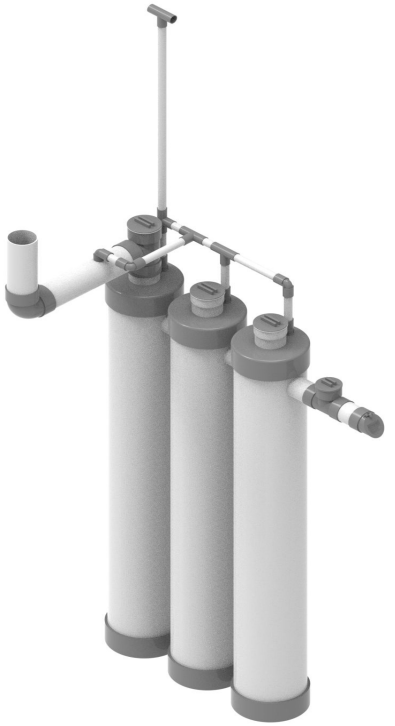
Specification

- Capacity : 196 L
- Treatment tank height : 2 meter
- Material : PVC
- Est. detention time : 58 hours
- Est. cost* : IDR 4.5 million

Description

This modified Tripikon uses only **two treatment tanks**. Wastewater enters through the inlet, fills the first tank, and then moves to the second tank before being discharged. The **main decomposition occurs primarily only in the second tank**, which has a relatively small capacity. This design is **more cost-effective than using three**.

Tripikon with Three Treatment Tanks



Specification

- Capacity : 294 L
- Tank height : 2 meter
- Material : PVC
- Est. detention time : 88 hours
- Est. cost* : IDR 6.2 million

Description

This modified Tripikon **uses three treatment tanks**. Wastewater enters through the inlet, fills the first tank, then moves to the second and third tanks for decomposition before being discharged. **This two-stage decomposition process**, with larger capacity tanks, ensures effective treatment despite **higher costs**.

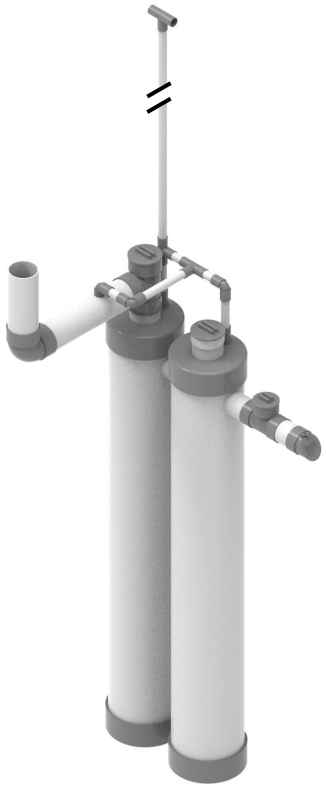
**The estimated cost is only for materials; labor and shipping costs are excluded.*

We conducted in-house prototype testing for both prototype designs (two and three treatment tanks) to assess the actual water capacity compared to the theoretical calculation and identify potential risk of leakage

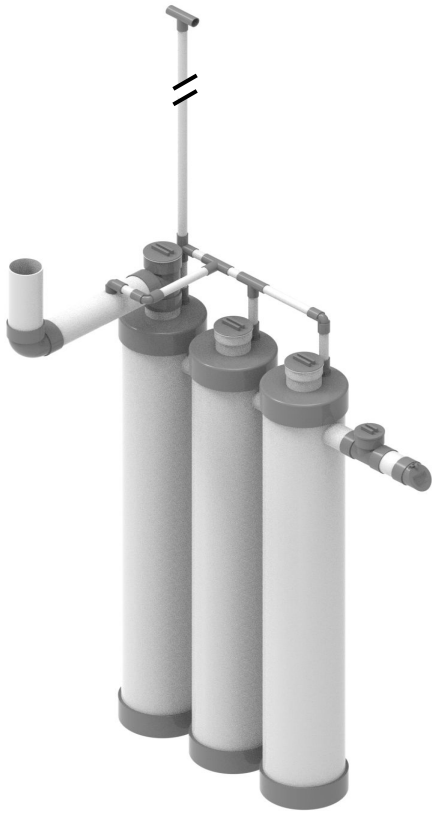
Experiment Design

Data collection period: 2 days

Indicators



Tripikon with two treatment tanks



Tripikon with three treatment tanks

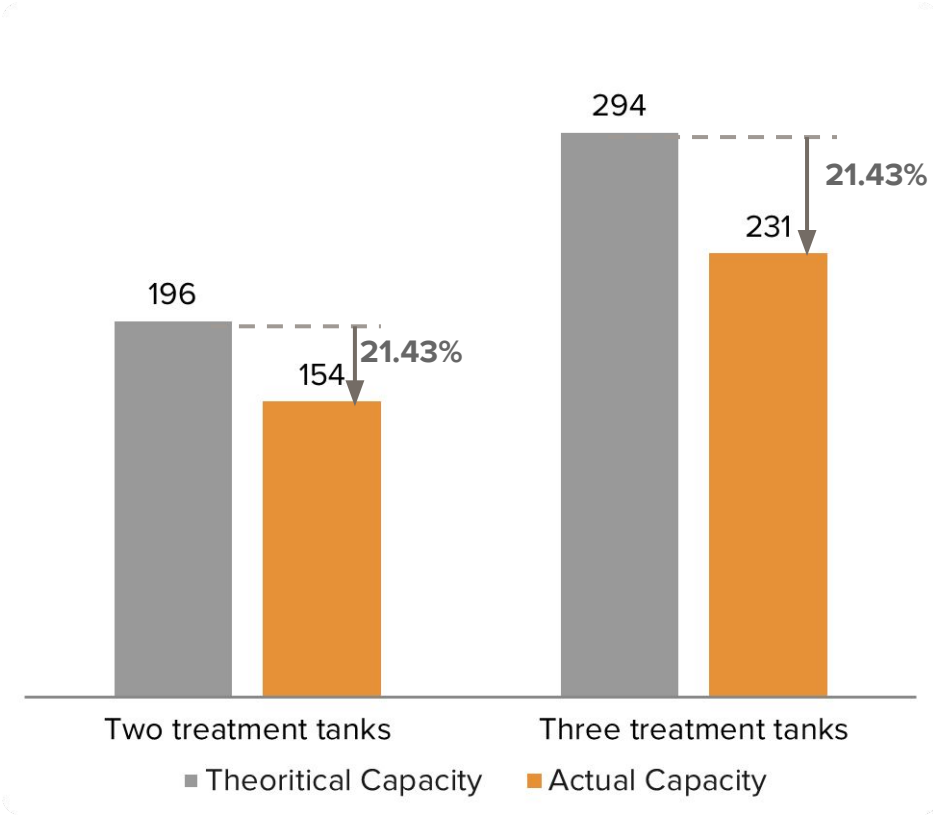
Actual water capacity (L)

Leakage spot (visually)

We selected the three-tank design for field implementation because the actual detention time still reaches the reference point, despite the lower quantity compared to theoretical capacity.

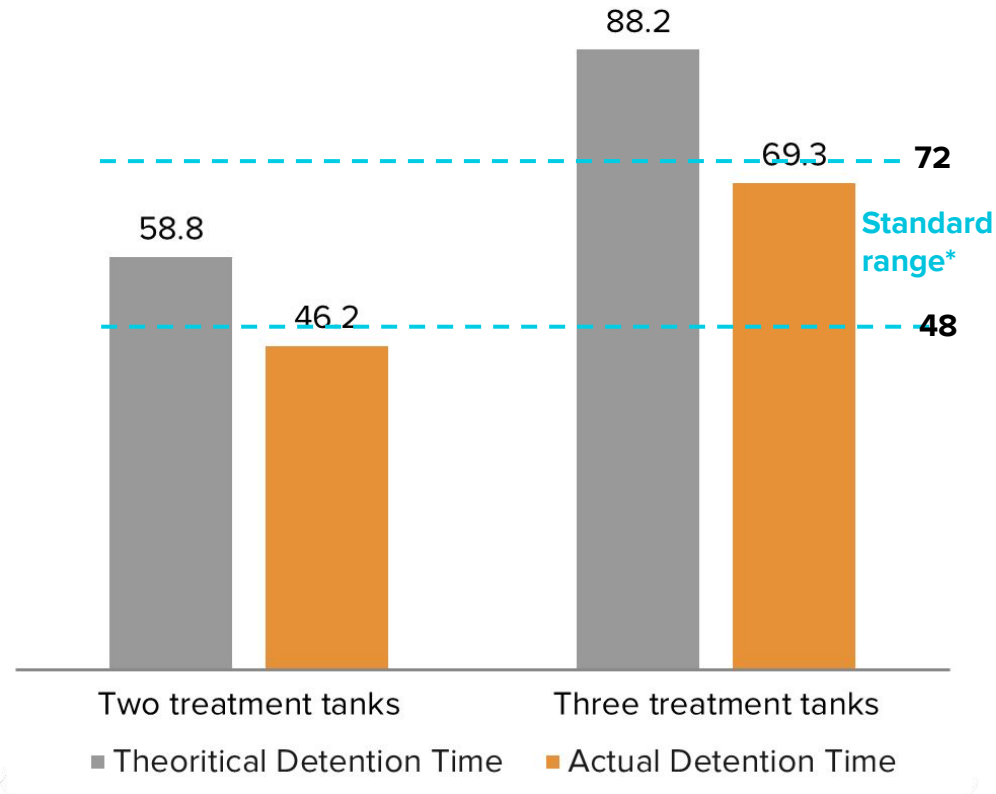
Theoretical and Actual Capacity

in liters



Theoretical and Actual Detention Time

in hour



Implications

The capacity discrepancy occurs due to several reasons:

- The design formula did not consider the empty space above the connection pipe.
- Additionally, the 10-inch pipe material has a length limitation, making the maximum treatment tank length less than the designed 2 meters, specifically 1.85 meters.

Refer to Indonesia National Standard (SNI) 2398:2017

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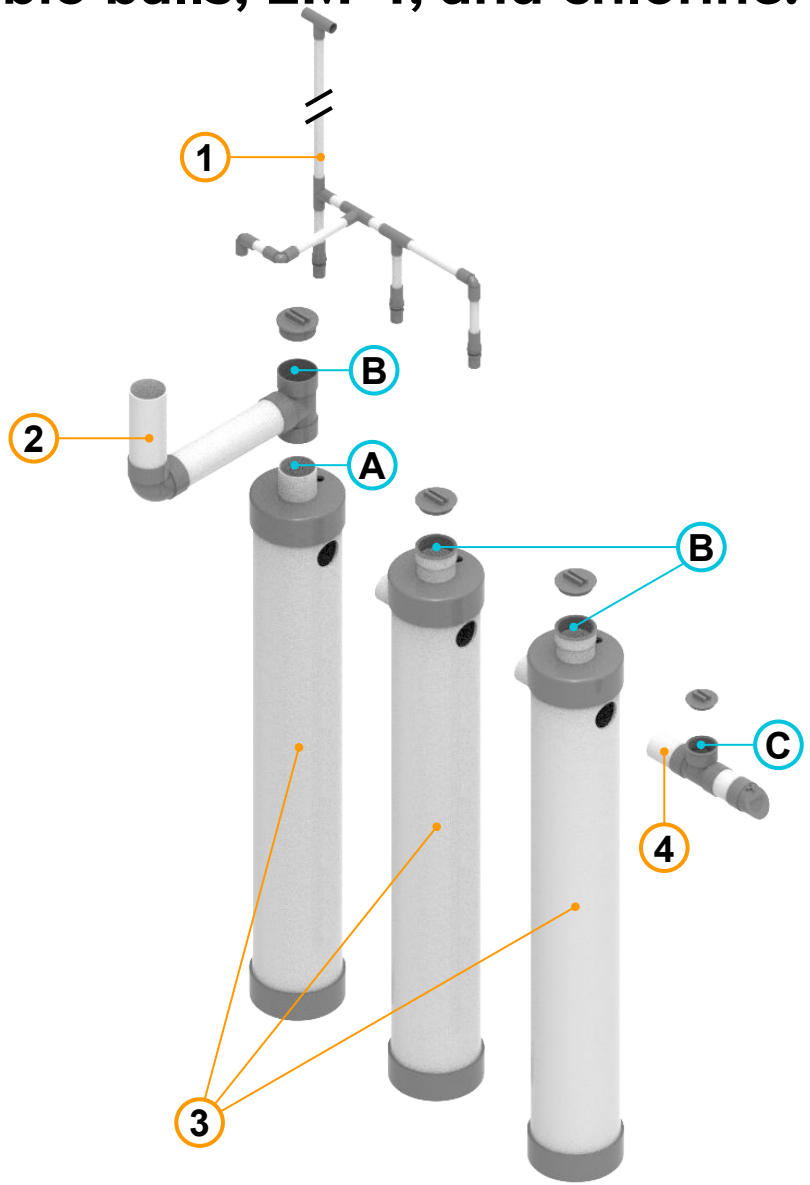
After the in-house experiment, we finalized the design and created construction guidelines. The final Tripikon design included three treatment tanks, pipes, and a wastewater system using bio balls, EM-4, and chlorine.

Constructed Tripikon in Kopernik office



Main components of a Tripikon set:

1. An array of ventilation pipes.
2. An array of wastewater inlet pipes.
3. Three array of treatment tanks.
4. An array of wastewater outlet pipes.

Tripikon system maintenance point:

- **A** 4” pipe on the first treatment tank where 1500 bio balls are placed.
- **B** Point where bio-activator solution (EM4+sugar) is poured every week.
- **C** Chlorinator, the location for placing chlorine tablets which are refilled every week.

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After conducting an in-house experiment and having found three appropriate houses to install the modified Tripikon, we constructed the Tripikon in the field

	 **Material preparation**	 **Components fabrication and shipment**	 **Tripikon sets assembly and installation at households**
Location	Pontianak*	Pontianak*	Batu Ampar
Activity	• Construction workers briefing. • Material procurement, adjustment, and delivery to workshop. • Measurement and cutting of pipes. • Creation of joint holes and wastewater circulation holes in pipes.	• Assemble pipes and other parts into 9 treatment tanks, 3 arrays of ventilation pipes, and 3 arrays of outlet pipes. • Ship the Tripikon components to Batu Ampar.	• Assemble all components into 3 sets of Tripikon. • Install all sets of Tripikon to each house structure.

Expected Output	• All materials are procured.
	• Construction workers are briefed.
	• All pipes are processed (cut and/or drilled).
		• Components fabricated:
		  ○ 9 arrays of treatment tanks.
		  ○ 3 arrays of ventilation pipes.
		  ○ 3 arrays of outlet pipes.
		• Tripikon components arrived in Batu Ampar.
			• Installed 3 sets of Tripikon to three houses structure.

Duration	2 days	2 days	3 days

** Considering the cheaper materials cost, the availability of equipment and working space, and expert partner support, we chose to fabricate Tripikon components in Pontianak city.*

We began constructing the Tripikon by briefing the workers, procuring materials, and preparing the materials by cutting and drilling pipes.

1. Construction Guideline Brief

- We prepared a Tripikon construction guide as a reference for the workers and briefed them prior the construction.
- This process aims to facilitate knowledge transfer, simplify and expedite the construction process.

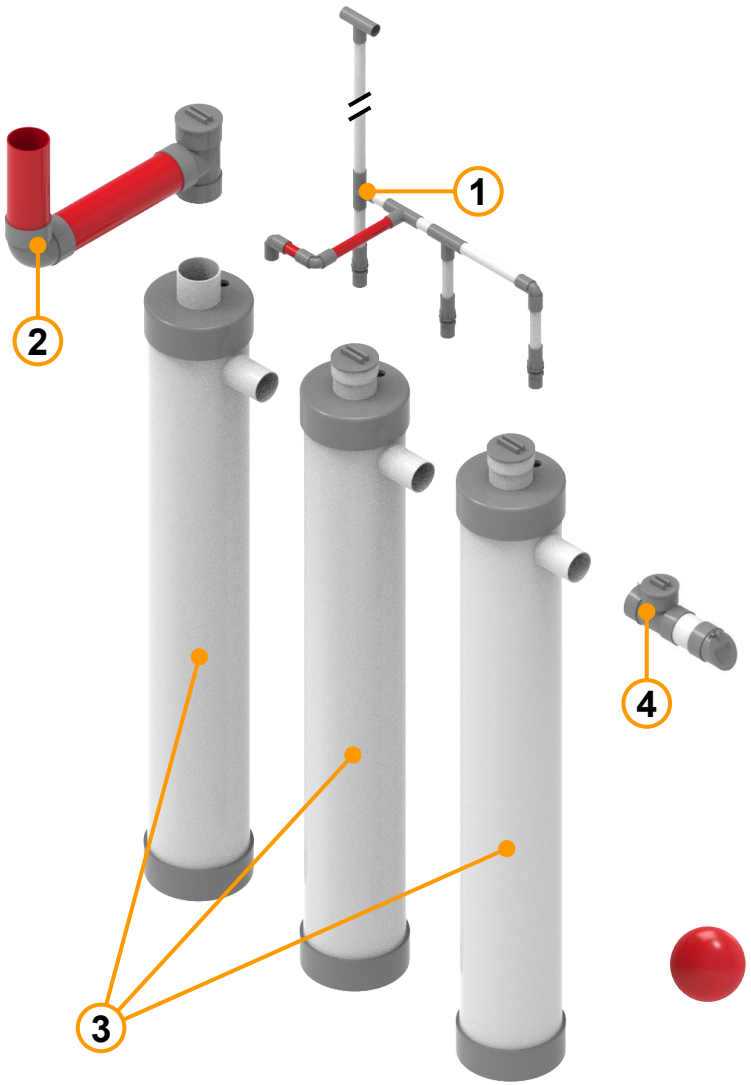
2. Materials Procurement

- The majority of materials (i.e pipes) were procured in Pontianak due to better availability and more competitive pricing.
- More common materials for household installations (i.e frame wood and gooseneck toilets) were bought in Batu Ampar.

3. Material Preparation

- During the material preparation process, all pipes were cut and drilled according to the dimensions in the guidelines.

We fabricated the main components at the workshop in Pontianak to make shipping and installation in Batu Ampar easier.



Component Fabrication

- This fabrication process produced 3 sets of Tripikon, consisting of 9 arrays of treatment tanks and 3 arrays of ventilation pipes, and 3 arrays of outlet pipes.

Main components of a Tripikon set:

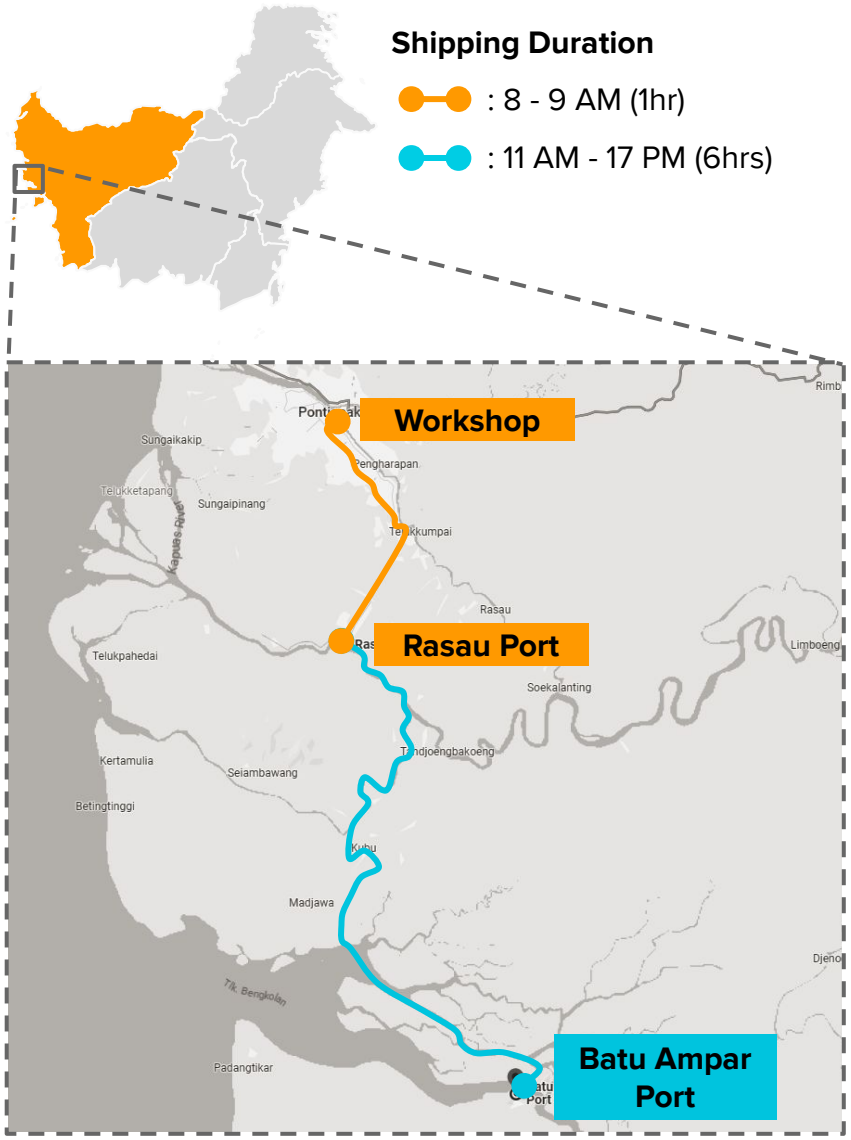
1. An array of ventilation pipes.
2. An array of wastewater inlet pipes.
3. Three array of treatment tanks.
4. An array of wastewater outlet pipes.

: The red pipe in the image remained uncut in Pontianak. Its length was adjusted during installation in Batu Ampar.

All of the treatment tanks that have been fabricated.

The ventilation and outlet pipe arrays were packed in a box.

We transported the components from the workshop to the Rasau port by pickup car, then shipped them by motorboat to Batu Ampar.



Workshop - Rasau Port

Components were transported from a Pontianak workshop to Rasau Jaya Port by pickup car.

Componen shipped from Rasau Port to Batu Ampar Port by motor boat.

Rasau Port - Batu Ampar Port

The arrays of treatment tanks and long pipe materials were placed on the upper deck of the motor boat.

The connecting pipe between treatment tanks and 10-inch DOP, which was attached only with PVC welding, has come off and cracked.

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We repaired the damaged components, distributed them to each household, and installed them on the house structures.

1 Repaired the damaged component

2 Distributed components to each household

3 Installed the treatment tank on the house structure

4 Connected the toilet outlet hole to Tripikon inlet pipe

5 Installed the Tripikon ventilation system

6 Installed the the Tripikon outlet pipes

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There were three main activities during prototype testing: designing the experiment, collecting data, and analyzing the results.

Experiment Design

Household scouting:

- We established selection criterias based on the Tripikon's capacity and the technical requirements for installation and scouted three household accordingly.

Designing experiment:

- We measured performance of Tripikon in treating wastewater in Batu Ampar, as well as the impact of adding bio balls.

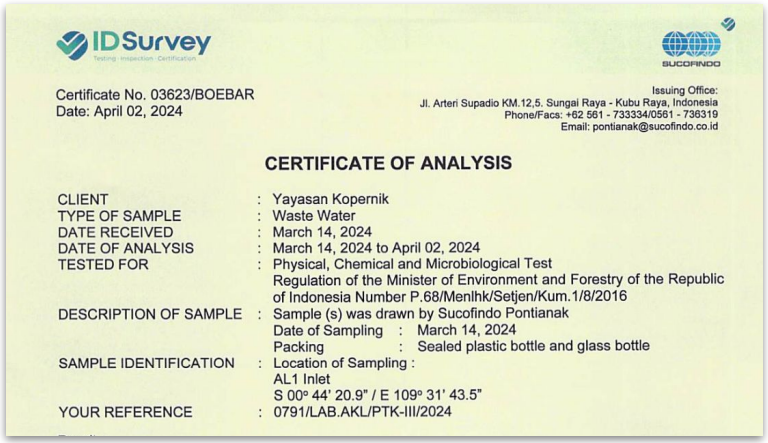
Data collection

Maintenance system:

- We created a maintenance guideline for households, which includes the bacteria formula, chlorine usage, and a list of do's and don'ts.

Field sampling:

- We enlisted Sucofindo (private laboratory in Pontianak) services and engaged with Puskesmas (public health centre Batu Ampar) to conduct sampling at agreed times.



IDSurvey

SUCOFINDO

Certificate No. 03623/BOEBAR
Date: April 02, 2024

Issuing Office:
Jl. Arteri Supadio KM.12,5. Sungai Raya - Kubu Raya, Indonesia
Phone/Facs: +62 561 - 733334/0561 - 736319
Email: pontianak@sucofindo.co.id

CERTIFICATE OF ANALYSIS

CLIENT	:	Yayasan Kopernik
TYPE OF SAMPLE	:	Waste Water
DATE RECEIVED	:	March 14, 2024
DATE OF ANALYSIS	:	March 14, 2024 to April 02, 2024
TESTED FOR	:	Physical, Chemical and Microbiological Test Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.68/Menlhk/Setjen/Kum.1/8/2016
DESCRIPTION OF SAMPLE	:	Sample (s) was drawn by Sucofindo Pontianak Date of Sampling : March 14, 2024 Packing : Sealed plastic bottle and glass bottle
SAMPLE IDENTIFICATION	:	Location of Sampling : AL1 Inlet S 00° 44' 20.9" / E 109° 31' 43.5"
YOUR REFERENCE	:	0791/LAB.AKL/PTK-III/2024

Result

Data analyze:

- The analyzed parameters would refer to the Ministry of Environment and Forestry regulations P.68/Menlhk-Setjen/2016, which include biological, physical, and chemical parameters.

In conducting experiments, there were several criterias that the house had to meet. We found three houses that met the same baseline criterias.

Criteria for choosing a house to install Tripikon

No.	Criteria	Reason
1.	Occupied by 4 people	Influence the capacity required to accommodate wastewater. Number of household member follow the average West Kalimantan statistic: 4.3 people/ HH
2.	Adequate room beneath the floating structure (2 -3 m)	Affect the maximum length of the pipe used for the Tripikon
3.	The house shares similar tidal flow pattern	Determine the installation height of the Tripikon

House conditions that meet the criteria

No.	Owner	House member	Distance (wooden floor-bottom of water body)	High tide water level	Water level (extreme weather)
1.	Suheri	4 people	300 cm	50 cm	0 cm
2.	Suherman	4 people	230 cm	30 cm	0 cm
3.	Suratno	4 people	200 cm	50 cm	20 cm

We installed modified Tripikon S in three stilt houses and collected the data to understand the effectiveness of the prototype compared to the current practice.

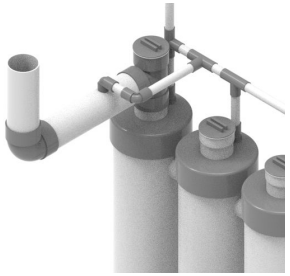
Data collection period: 2 months

Experiment design

Intervention

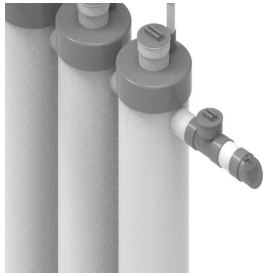
- Tripikon was installed in three stilt houses
- Three participating households are using the toilet for daily activities and has similar number of residents during implementation period

Inlet Tripikon



- Wastewater **before** treatment through Tripikon
- Three tripikon (n=3)
- Sampling was conducted three times: day 6, day 15, and day 43

Outlet Tripikon



- Wastewater **after** treatment through Tripikon
- Three tripikon (n=3)
- Sampling was conducted three times: day 6, day 15, and day 43

Output

Tripikon installed and function effectively

Wastewater Quality Indicator*

a. *Biological Parameters (limit):*
- Total Coliform

b. *Physical Parameters (limit):*
- TSS (Total Suspended Solids)

c. *Chemical Parameters (limit):*
- pH
- BOD (Biological Oxygen Demand)
- COD (Chemical Oxygen Demand)
- Oil & grease
- Ammonia (NH_3)

Outcome

Tripikon is adopted by the community to improve sanitation access

User Response Indicators

a. *Visual perception of wastewater*

b. *Smell perception of wastewater*

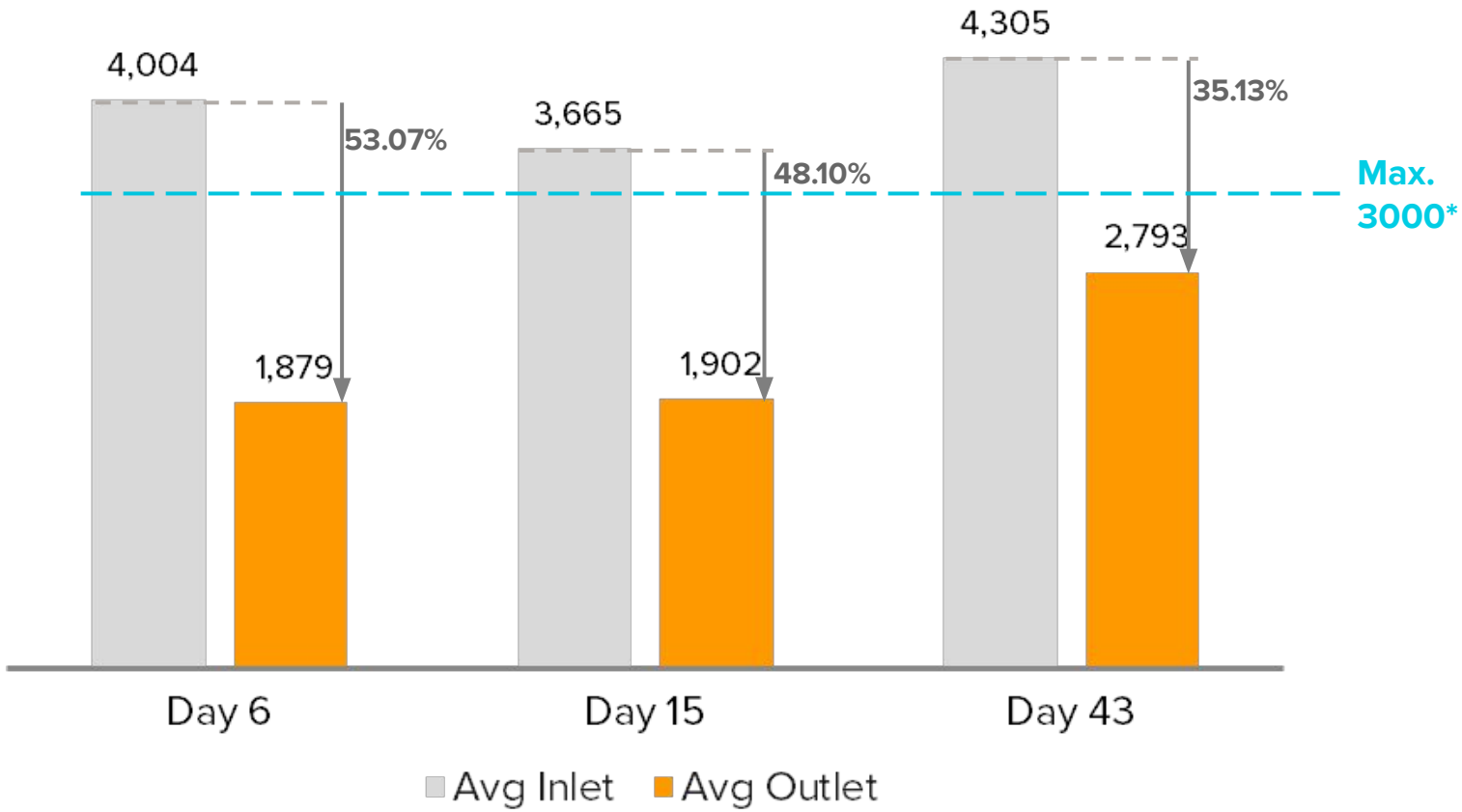
Community willingness to adopt

*Refer to Permen No P.68/Menlhk, (2016)

Biological parameters: During the three samplings, all the outlets met the requirement. Overall, on average, it reduced total coliform by 45.43%.

Average total coliform at three different sampling times

in total/100 mL



Effect on processed wastewater

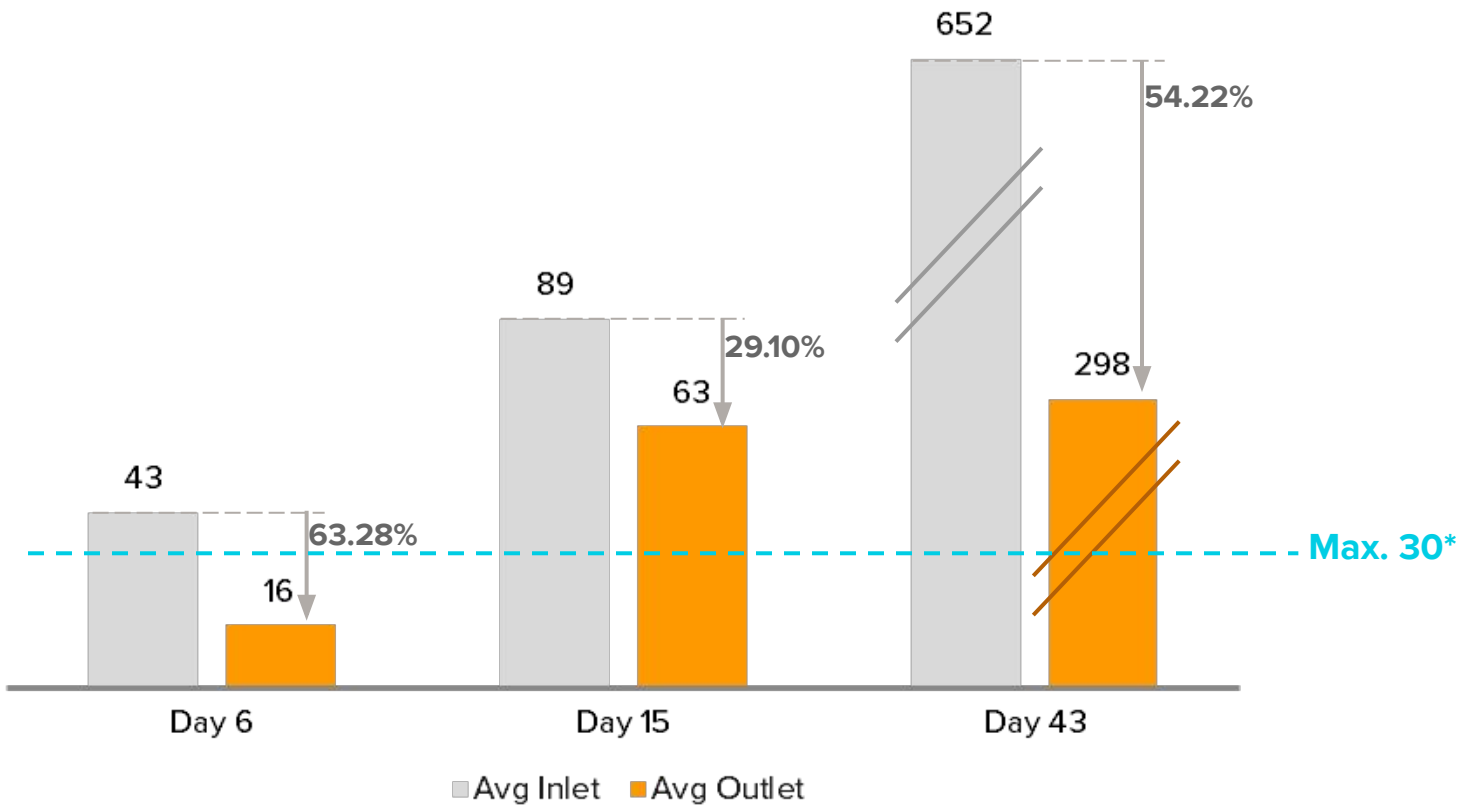
- The national standard for total coliform is 3000 MPN/100 mL, and in this experiment, the levels remained within this limit, showing that **Tripikon can effectively reduce microbial contamination and may help prevent bacteria that cause diarrhea.**
- **The trend in total coliform might follow a typical bacterial growth pattern.** On Day 6, the bacteria could be in an adaptation phase with low activity. By Day 15, there was a slight decrease, possibly indicating that bacterial activity has stabilized. By Day 43, the bacterial population may have reached a point where growth stops, **and after that, it would likely begin to decrease due to unfavorable conditions.**

*Refer to Permen No P.68/Menlhk, (2016)

Physical parameters: During the last sampling, TSS increased drastically. However, on average, the tripikon could reduce the amount of TSS by 48.87%.

Average Total Suspended Solids (TSS) at three different sampling times

in mg/L



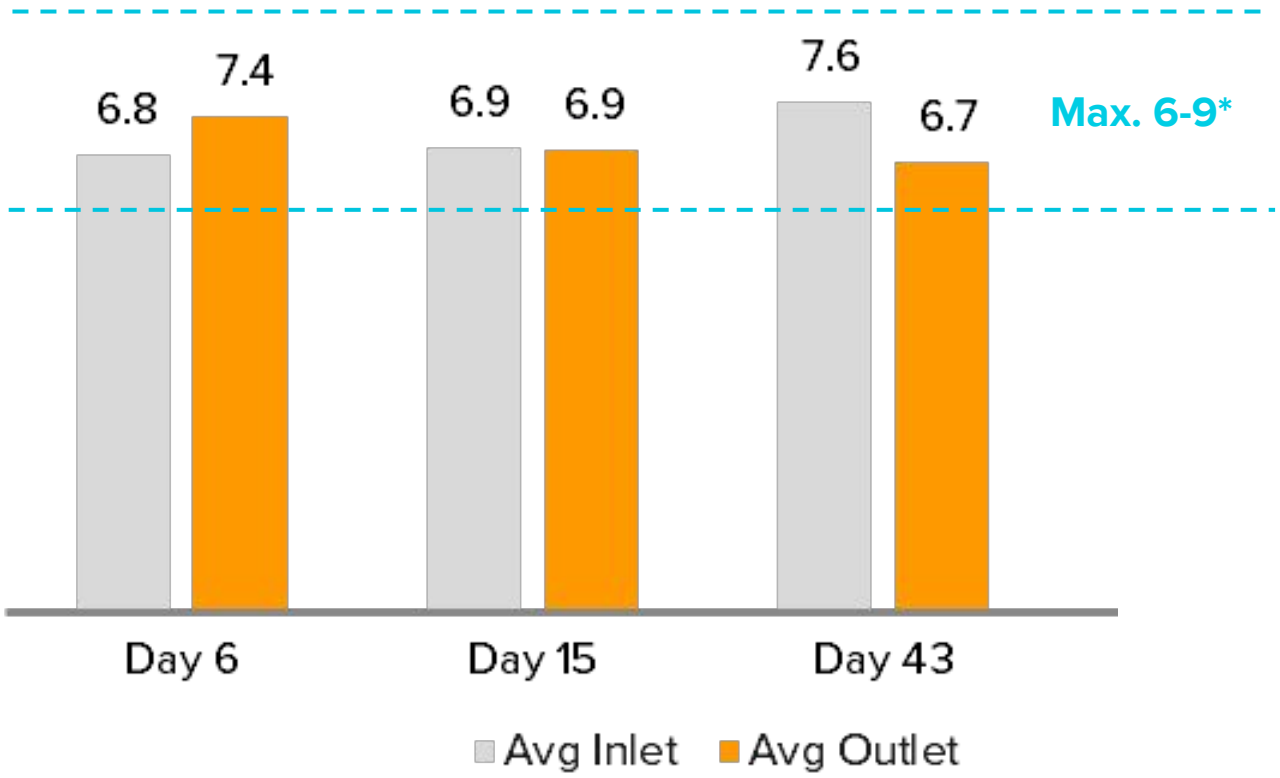
*Refer to Permen No P.68/Menlhk, (2016)
// in the bar chart indicates an axis break

Effect on processed wastewater

- In this experiment, the trend of TSS and BOD was similar. High levels of TSS in all groups indicated the presence of high particle in the processed wastewater.
- Additionally, the high level of TSS could contribute to high BOD by providing a medium for microorganisms to grow and degrade organic matter, which in turn consumes oxygen in the water.

Chemical parameters: During the sampling, the pH levels of both the inlet and outlet met the required standard, ranging from 7 to 8.

pH at three different sampling times



Effect on processed wastewater

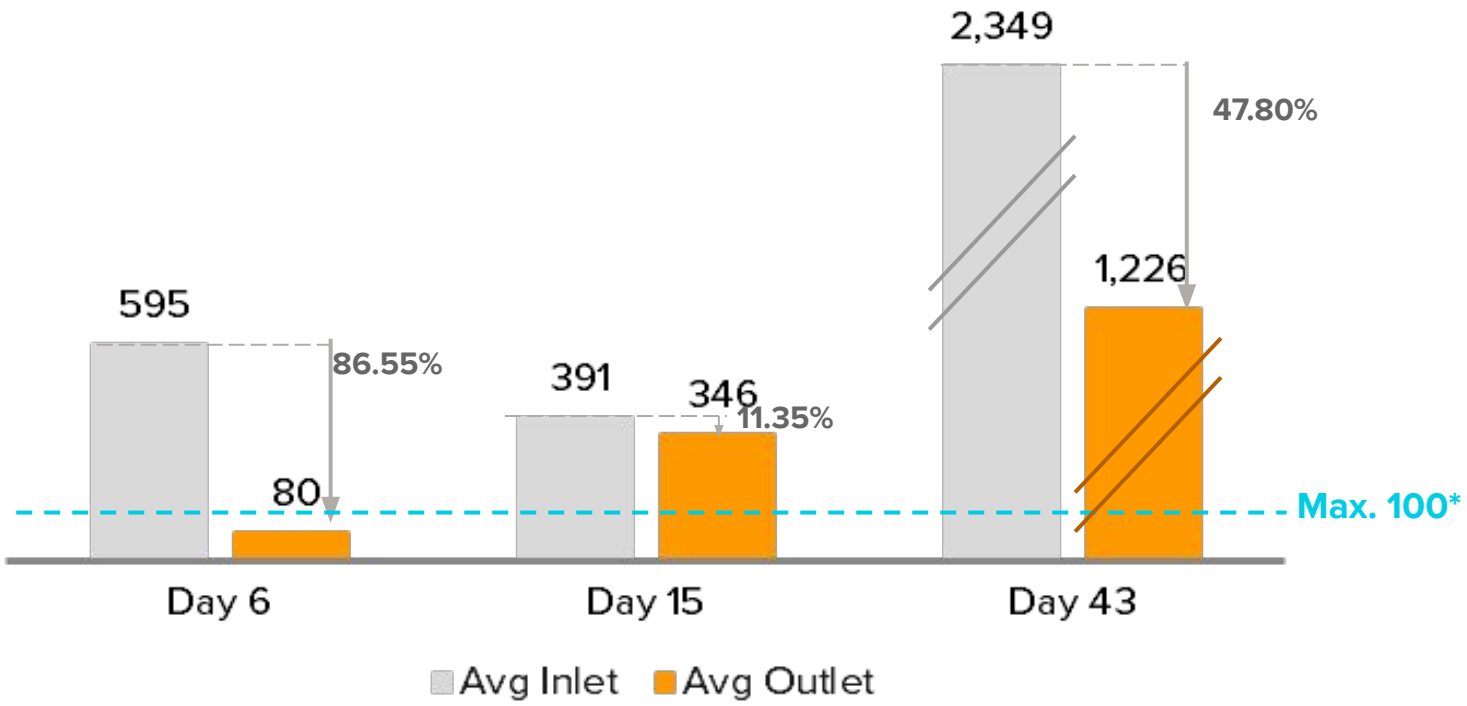
- For domestic wastewater, the requirement is typically between 6 and 9. Since inlet and outlet met the requirement, it is likely safe to discharge them into the environment. Although it appears safe, it is important to consider other parameters.

*Refer to Permen No P.68/Menlhk, (2016)

Chemical parameters: The amount of COD from the outlet seemed to increase during the sampling, and it drastically increased in the last sampling. However, on average, the tripikon could reduce the amount of COD 48.57%.

Chemical Oxygen Demand (COD) at three different sampling times

in mg/L



*Refer to Permen No P.68/Menlhk, (2016)
// in the bar chart indicates an axis break

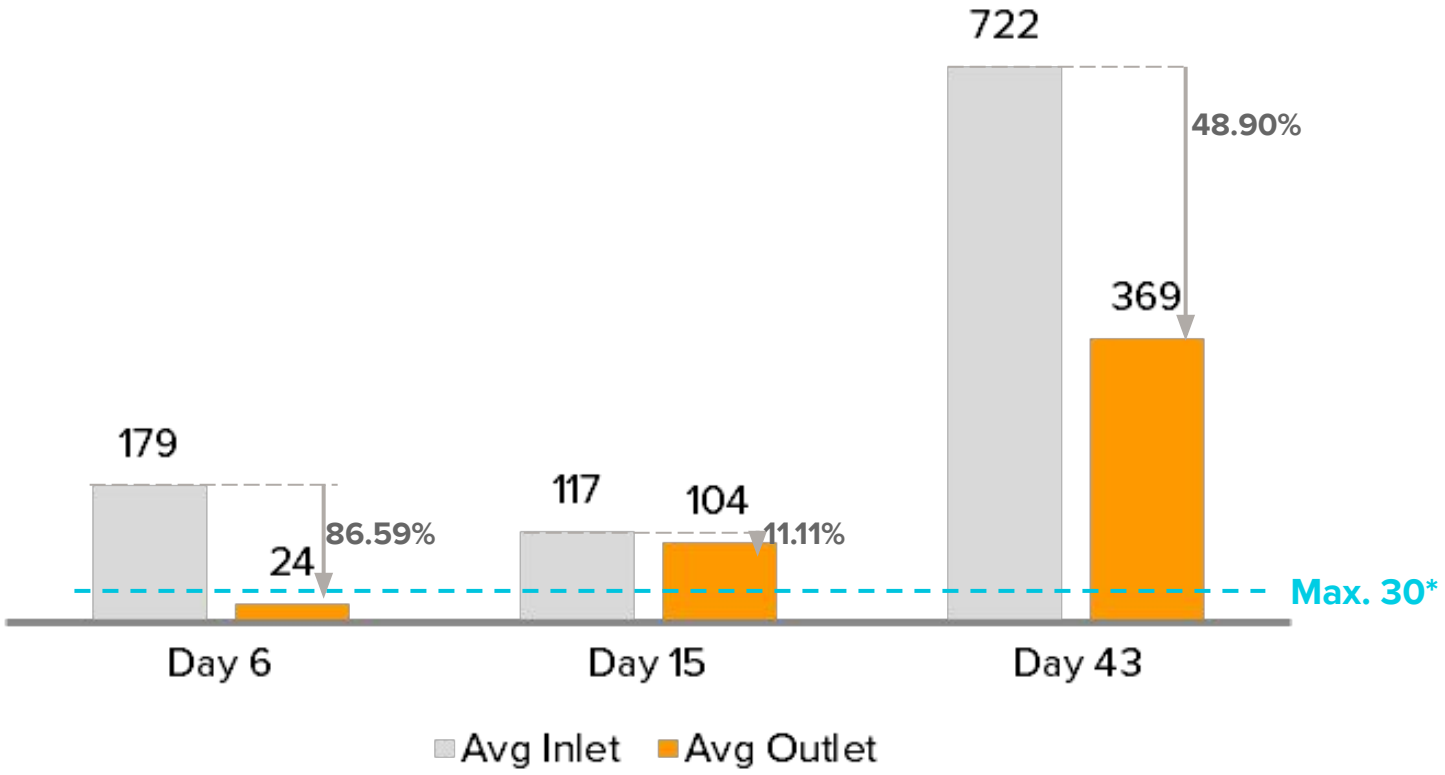
Effect on Processed Wastewater

- In this experiment, after a week of use, the COD value increased. The processed waste water indicates an excessive amount of organic matter present in the water, which consumes dissolved oxygen.
- Furthermore, a significant decrease COD, as observed in day 43, could potentially create competition for dissolved oxygen among aquatic organisms.

Chemical parameters: A similar pattern was observed with BOD, which initially appeared to increase. However, it was ultimately reduced by an average of 48.87%.

Biological Oxygen Demand (BOD) at three different sampling times

in mg/L



Effect on processed wastewater

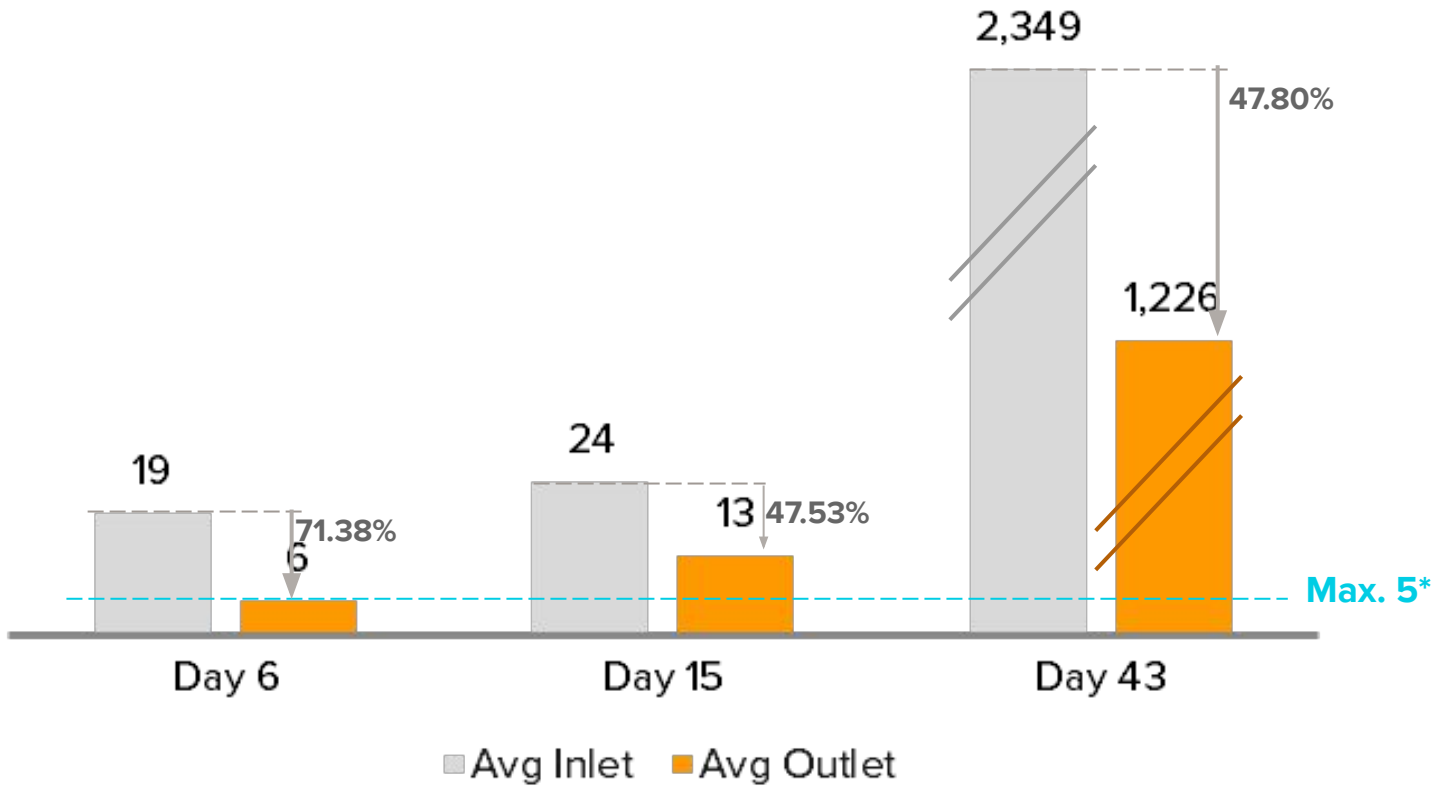
- High COD is usually followed by high BOD. In this experiment, the trend of BOD was the same with COD, with an increase observed after a week of use, especially in T(b).
- The aerobic bacteria consumed oxygen to break down the organic matter, reducing the availability of oxygen in the water, which produced toxic compounds and odors

*Refer to Permen No P.68/Menlhk, (2016)

Chemical parameters: Tripikon initially performed well in reducing oil and grease during the first sampling. However, in the last sampling there was a significant increase in inlet and outlet. Overall, on average, Tripikon could reduce oil and grease by 55.57%.

Oil and grease at three different sampling times

in mg/L



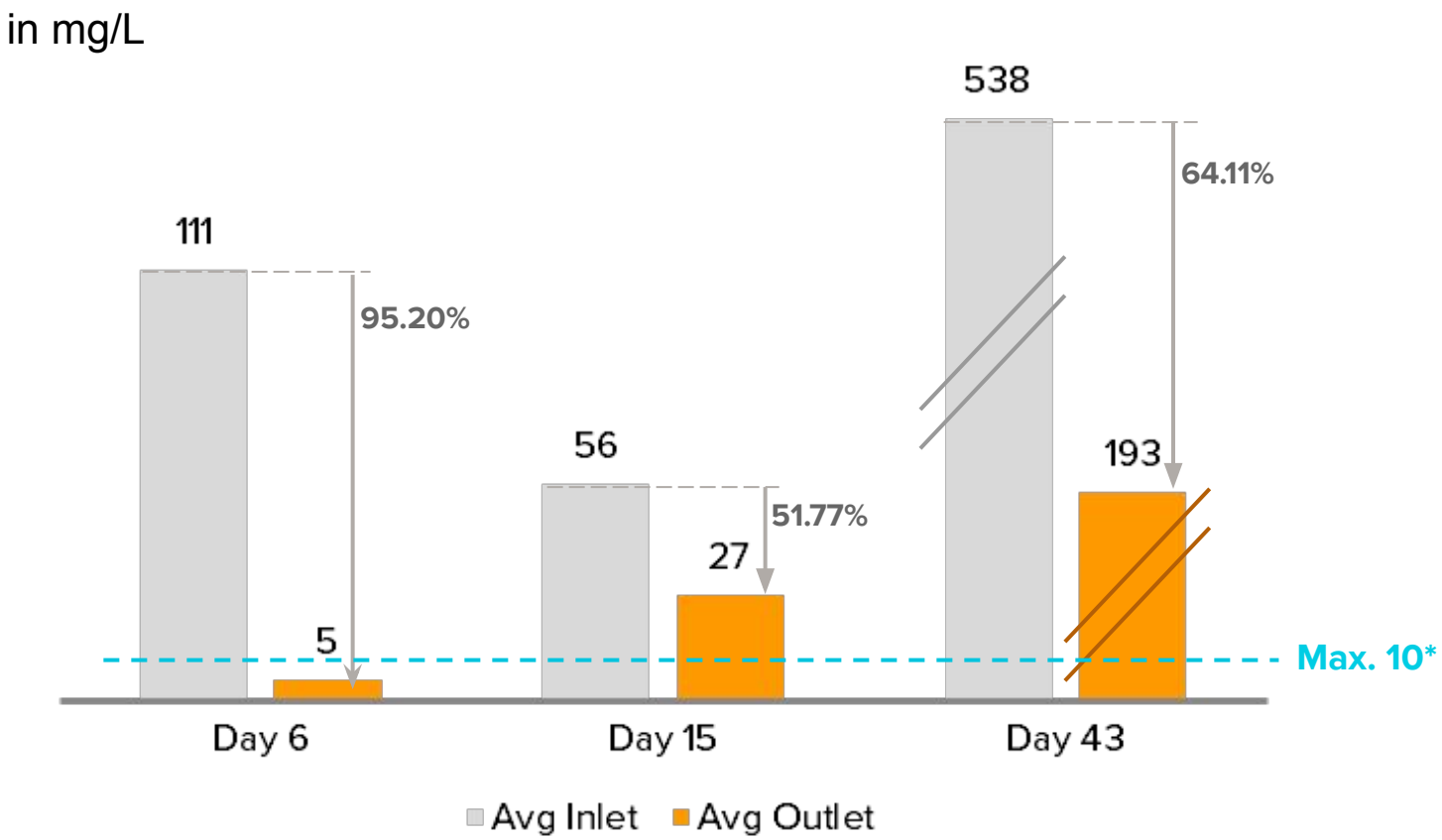
*Refer to Permen No P.68/Menlhk, (2016)
// in the bar chart indicates an axis break

Effect on processed wastewater

- In this experiment, the presence of oil and grease increased until the end of the sampling period. This can potentially form a layer on the surface, reducing oxygen transfer and harming aquatic life.

Chemical parameters: There was a significant increase in ammonia observed in the last sampling, although overall, on average, Tripikon could reduce ammonia by 70.36%

Ammonia at three different sampling times



*Refer to Permen No P.68/Menlhk, (2016)
// in the bar chart indicates an axis break

Effect on processed wastewater

- In this experiment ammonia level in day 43 drastically increased after two weeks of using tripikon.
- High levels of ammonia could be caused by several factors such as higher organic loadings, which align with the levels of BOD and COD, indicating an excessive presence of organic matter in wastewater.

Household feedback: We received several feedback from household after 3 months of Tripikon installation. **Suharno's tripikon experienced significant odor problem, while others households did not report any issue**

Suharno

"After a month of use, an unwanted smell appeared from the outlet. Therefore, additional materials such as lime and EM4 are required. However, obtaining EM4 here is quite difficult as it needs to be transported from the city. Hopefully, there is a simple way to prevent the smell if it happens again"

Suheri

"Thank you, Kopernik, for installing Tripikon. Since the installation, there have been no significant issues. Occasionally, there is a smell, but this is understandable for a septic tank and hasn't been bothersome"

Suherman

"This tool (Tripikon) was good; we had no problems using it. Some smells may appear, but we can manage them properly. However, this tool is expensive for us to make. Therefore, thank you to Kopernik for helping us with this"

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Field implementation was challenged by Tripikon shipping component and uncertain sea tides during the installation

		Challenges	Solutions
Material	Availability	• **Limited availability of EM4 in Batu Ampar** EM4 is essential for Tripikon maintenance; unfortunately, it is not available for purchase in Batu Ampar.	We purchased EM4 from Pontianak City and transported it to Batu Ampar
	Shipping	• **Some part of tripikon were broken during shipping** Due to its large size and heavy weight, transferring Tripikon was quite challenging. During loading from the ship to the mainland, several parts, especially the joints, were cracked	We stored Tripikon in Balai Desa for some repairs and to check for any possible cracks
Sea tides condition		• **Uncertain sea tides condition** Usually, sea tides recede at dusk, which is the best time to install Tripikon. However, during the implementation, the tides tended to recede at night, and some rain occurred, which made the installation run a bit slower	Moved the installation agenda to nighttime

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The modified Tripikon showed good performance in reducing total coliform, a major bacteria that can cause diarrhea, by keeping its value below the SNI. The modified Tripikon also showed notable reduction in other wastewater indicators, indicating an improvement compared to the current direct discharge practice. However, further modifications are necessary to enhance Tripikon's effectiveness.

We have **developed and tested Tripikon in three different households in Batu Ampar, West Kalimantan.** The testing **attracts interest** from government stakeholders and the households **showed a willingness** to maintain the Tripikon.

Installing Tripikon in stilt houses has helped the households **achieve better sanitation, aligning with the government's mission to reduce open defecation in Batu Ampar**. While the construction cost of a **Tripikon unit (USD 600) is manageable**, it can be **expensive for individual households** in remote areas. Therefore, **strong government support** is crucial to ensure wider adoption and implementation of this tool.

Installation process in household

Following up the prototyping, we plan to update the maintenance protocol and share the findings with local stakeholders through online dissemination.

Lesson learned

- The increase of measured parameters by the end of sampling period (day 42) indicate the stagnant phase of bacterial activities.
- The initial community engagement showed high interest from local government and health facilities due to severity of the problem and priority
- Adding EM4 for maintenance is important to ensure Tripikon works properly. However, since EM4 is difficult to find, exploring alternative bacteria starters that are readily available could be beneficial.

Next steps

- To improve the Tripikon performance, we recommend to add EM4 dilution and chlorine for every 1- 2 months
- We will share the findings through dissemination and invite local government (Bappeda, Department of Health, Department of Housing and Public Works) in regency level and village level
- Explore potential bacterial starters that are easier to find, such as eco enzyme, and test their effectiveness in treating household blackwater waste.

ANNEX

ANNEX

Summary result of the laboratory analysis of main parameters for wastewater quality

Summary result

No.	Parameter	Regulation	Tripikon 1			Tripikon 2			Tripikon 3		
			Sampling 1	Sampling 2	Sampling 3	Sampling 1	Sampling 2	Sampling 3	Sampling 1	Sampling 2	Sampling 3
1.	Total coliform	3000	3000	1810	2951	758	2014	2525	3000	1882	2903
2.	TSS	30	30	71	405	3	79	70	14	40	420
3.	pH	6-9	6.9	6.74	6.07	7.85	6.66	7.95	7.57	7.25	6.05
4.	BOD	30	30	163	341	14	93	65.3	28	56	700
5.	COD	100	100	543	1138	47	310	218	93	186	2323
6.	Oil and grease	5	5	8	11.4	2	4	10.8	3	4.6	16
7.	Ammonia	10	10	56	140	2	25	36.3	4	0.02	403

: Meet the standard : Doesn't meet the standard

ANNEX

The following is the description of each parameter used to assess the processed wastewater

No.	Category	Parameter	Description
1.	Biological parameter	Total Coliform	Total coliform is a biological parameter used to asses the microbiological quality of water. It is a measure of the total number of coliform bacteria present in a given volume of water. **High levels of total coliform indicate the presence of fecal matter in the water, which can pose health risks to humans and animals.**
2.	Physical parameter	TSS	TSS stands for Total Suspended Solids which is dry weight of suspended particles in a water sample that are not dissolved and can be trapped by a filter. These particles can include both organic and inorganic materials, such as sediment, algae, bacteria, and other suspended solids. **High level TSS can decrease water temperature and block sunlight which can harm aquatic life.**

ANNEX

The following is the description of each parameter used to assess the processed wastewater

No.	Category	Parameter	Description
3.	Chemical parameter	pH	pH is used to measure the acidity and basicity of a solution
		BOD	BOD stands for Biological Oxygen Demand which is the quantity of dissolved oxygen needed to completely break down organic matter in water using biological and chemical process that occur in water
		COD	COD stands for Chemical Oxygen Demand which is the amount of oxygen required to oxidize the organic matter in a sample of water using chemical oxidizing agents
		Oil and grease	Oil and grease are types of pollutants that can contaminate water. They can come from various sources such as food waste or soap
		Ammonia	Ammonia is a type of pollutant that can be found in water. High levels of ammonia can be toxic to aquatic life and must be treated before being released into the environment

ANNEX

Material Price Comparison (Batu Ampar vs Pontianak)

ITEM	PRICE/UNIT		MARGIN
	BATU AMPAR	PONTIANAK	
PIPE (Panjang 4 m)			
1" AW	Rp70,000	Rp50,410	Rp19,590
3" AW	Rp280,000	Rp225,380	Rp54,620
4" AW	Rp460,000	Rp378,585	Rp81,415
10" AW	Rp2,600,000	Rp1,844,740	Rp755,260
12" AW	Rp3,750,000	Rp2,711,985	Rp1,038,015
DOP			
3" AW	Rp18,500	Rp18,500	Rp0
4" AW	Rp40,000	Rp34,500	Rp5,500
10" AW	Rp160,000	Rp160,000	Rp0
12" AW. c bc y ik	Rp400,000	Rp400,000	Rp0
CO			
3" AW	Rp31,000	Rp31,000	Rp0
4" AW	Rp51,500	Rp51,500	Rp0
Elbow Pipe (Pipa L)			
1" AW	Rp8,000	Rp7,000	Rp1,000
4" D	Rp20,000	Rp49,000	Rp29,000
T			
1" AW	Rp10,000	Rp10,000	Rp0
4" x 3" D	Rp64,000	Rp64,000	Rp0
4" D	Rp30,000	Rp64,000	Rp34,000
Backflow			
3"	Rp37,500	Rp37,500	Rp0
Socket (SDD & SDL)			
SDD 1"	Rp7,000	Rp7,000	Rp0
SDL 1"	Rp7,000	Rp7,000	Rp0

Actual Cost for Field Implementation

COST ITEM	COST FOR 3 SETS	COST FOR 1 SET
Materials		
Pontianak - Pipe - Pipe fitting - Pipe glue - Chlorine - EM4 - Sugar - Iron plate	IDR 18,082,020	IDR 6,027,340
Batu Ampar - Wooden beam - Gooseneck toilet - Additional pipe fitting - Nails - Rust-proof paint + tiner - Drill bit - Bucket & jerrycan - Cement	IDR 1,458,400	IDR 486,133
Total Materials	**IDR 19,540,420**	**IDR 6,513,473**

Logistic Shipment Cost		
Pontianak - Rasau Port	IDR 350,000	IDR 350,000
Rasau Port - Batu Ampar	IDR 200,000	IDR 200,000
Batu Ampar	IDR 200,000	IDR 200,000
Total Logistic Shipment Cost	**IDR 750,000**	**IDR 750,000**

Labor cost		
Pontianak Workers	IDR 2,500,000	IDR 1,500,000
Batu Ampar Workers	IDR 500,000	IDR 500,000
Total Labor Cost	**IDR 3,000,000**	**IDR 2,000,000**

Total Cost	**IDR 23,290,420**	**IDR 9,263,473**

ANNEX Maintenance Cost Calculation

The maintenance of the modified Tripikon S was conducted every once a month to ensure the decomposition process in the treatment tank can proceed optimally. Activities included in the maintenance are:

- Adding chlorine to the array of outlet pipes.
- Pouring bioactivator solution into treatment tanks.

Bioactivator solutions:

- Mix 1,000 ml of EM4 + 100 gr of sugar + 10 litre of water.
- Let the mixture sit for 2-3 hours until the solution is ready to use.
- Pour 2 litre solution into each treatment tank. Pour into treatment tanks 2 and 3.

The details of the materials and costs required and available in the market for the maintenance process are as follows:

Materials and costs

Item	Unit	Remarks	Price
Chlorine	50	tablet/pack	Rp75,000
EM4*	1,000	ml/bottle	Rp30,000
Sugar	1,000	gr/pack	Rp20,000
Water**	10	litre	Rp0

** The EM4 used is EM4 for waste treatment, packaged in white bottle with a blue label.*

*** The water used incurs no cost, assuming clean water is already available.*

The materials and costs required for monthly are as follows:

Item	Cost per Maintenance			
	Unit	Remarks	Frequency (times)	Price
Chlorine	4	tablet	2	Rp12,000
EM4	330	ml	1	Rp9,900
Sugar	33	gr	1	Rp660
Total				**Rp22,560**

In 1 year, 24 maintenance activities need to be conducted, requiring materials and costs estimated as follows:

Item	Yearly Cost			
	Unit	Remarks	Frequency (times)	Price
Chlorine	4	tablet	24	IDR 144,000
EM4	330	ml	12	IDR 118,800
Sugar	33	gr	12	IDR 7,920
Total				**IDR 270,720**