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GREEN PRODUCTIVITY ANALYSIS BASED ON ENVIRONMENTAL RISK ANALYSIS AND ENVIRONMENTAL PERFORMANCE IN THE LIQUID WASTE ASPECT OF PT NATA DE COCO X

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Abstract

The food and beverage industry, including Nata de Coco production in Indonesia, plays a vital role in the economy. PT Nata de Coco X, as a market leader in this sector, needs to implement the Green Productivity concept to meet green industry standards. This study aims to evaluate the implementation of Green Productivity based on environmental risk and performance analysis. Considering that the liquid waste discharge almost exceeds the established quality standards, the environmental risk is indicated as high. Data triangulation methods (questionnaires, observations, and interviews) indicate that out of 16 processes, 6 are classified as low, 9 are classified as moderate, and 1 is classified as medium in the qualitative environmental risk analysis. The semi-quantitative method produces an overall environmental risk score of 102, which is classified as low risk. The environmental performance assessment shows a score of 94.4, categorized as very good. These findings are reinforced by observations and interviews. A Green Productivity strategy was developed using cause-and-effect analysis and a fishbone diagram, with 11 main strategies identified. The 5W1H analysis is used to develop a strategy, resulting in 1 first priority solution, namely utilizing wastewater from washing packaging, ablution and washing vegetables for watering plants, the last priority solution is installing pipes/hoses as a suitable wastewater drainage path.

Keywords: Nata de Coco, Green Productivity, Environmental Risk Analysis, Environmental Performance Instruments, Triangulation,

INTRODUCTION

At the Investor Day event in Jakarta, Minister of Industry Airlangga Hartarto stated that the food and beverage industry is projected to be a leading sector in manufacturing growth and the national economy [1]. The nata de coco industry, including PT Nata de Coco X as the largest producer, is projected to experience annual growth of 6.30% from 2023 to 2032 [2], given that Indonesia is one of the world's largest producers of processed coconuts [3]. PT Nata de Coco X recognizes that despite being a market leader, it does not yet have the green industry certification mandated by Law No. 3 of 2014. This certification is crucial for enhancing global competitiveness and corporate image. To achieve green industry standards, a Green Productivity approach is required, which combines productivity improvements with environmental performance.

However, PT Nata de Coco X's increased production also generates significant liquid waste. In November 2023, the average wastewater discharge reached 271 m^3/day, approaching the maximum limit of 287 m^3/day stipulated in Minister of Environment Regulation No. 5 of 2014. The potential for production expansion could exceed this limit, posing a risk to environmental quality. Therefore, an Environmental Risk Analysis (ARL) is required to identify the risks and environmental impacts of liquid waste. This aims to identify areas in the process that require productivity improvements, thus providing a basis for developing a Green Productivity-oriented strategy. To analyze environmental performance, the Environmental Performance Assessment Instrument is used. This instrument is based on two. The main guidelines are Regulation of the Head of the Industrial Research and Development Agency No. 88/BPPI/PER/3/2018 concerning Guidelines for Green Industry Award Assessment and Regulation of the Minister of Environment and Forestry No. 1 of 2021 concerning the Company Performance Rating Assessment Program in Environmental Management. These environmental performance instruments play a role in supporting Green Productivity, which is an effort to increase the efficiency of liquid waste management while taking environmental aspects into account.

LITERATURE REVIEW

Environmental management has become a critical concern in industrial activities, particularly in sectors that generate significant liquid waste such as the food and beverage industry. Effective wastewater management is essential not only to comply with environmental regulations but also to ensure sustainable resource utilization and minimize ecological impacts. According to the concept of environmental risk assessment, risks arise from the interaction between industrial processes and environmental components, which may lead to pollution if not properly controlled. Risk assessment methods are generally classified into qualitative, semi-quantitative, and quantitative approaches, each offering different levels of accuracy and complexity. The semi-quantitative risk assessment method is widely used in environmental studies because it provides a balance between simplicity and analytical rigor. This method combines qualitative judgments with numerical scoring to evaluate the likelihood and severity of environmental risks. By assigning scores to various risk parameters, researchers can prioritize environmental issues and identify critical areas requiring immediate attention. This approach is particularly useful in industrial wastewater management, where multiple risk sources exist across production and supporting processes.

In addition to risk assessment, the concept of Green Productivity (GP) has been increasingly adopted as a strategic approach to improve both environmental performance and operational efficiency. Green Productivity integrates environmental considerations into productivity improvement efforts by reducing waste, optimizing resource use, and minimizing environmental impacts. The framework emphasizes the importance of continuous improvement, technological innovation, and employee involvement in achieving sustainable industrial practices.

Previous studies have demonstrated that the implementation of Green Productivity in wastewater management can significantly reduce water consumption and pollutant discharge. Strategies such as water recycling, reuse of condensate water, and utilization of low-contaminant wastewater (grey water) for non-potable purposes have proven effective in enhancing environmental performance. These practices not only decrease the dependency on clean water sources but also reduce the load on wastewater treatment facilities, contributing to overall sustainability.

Furthermore, the use of analytical tools such as Fishbone Diagram (Cause-and-Effect Analysis) and 5W1H (What, Why, Where, When, Who, and How) has been widely applied to identify root causes of environmental problems and develop appropriate solutions. The Fishbone Diagram helps categorize potential causes into key factors such as human, machine, method, material, and environment, while the 5W1H method provides a structured approach to formulating actionable solutions. These tools are essential in ensuring that proposed improvements are both systematic and feasible.

Several researchers have also highlighted the importance of water balance analysis in understanding water usage patterns within industrial systems. Water balance enables companies to identify inefficiencies, quantify water losses, and develop strategies for conservation and reuse. Combined with proper wastewater treatment systems, such as Wastewater Treatment Plants (WWTP/IPAL), industries can significantly improve their environmental performance and compliance with regulatory standards.

Despite the availability of various methods and technologies, challenges remain in implementing sustainable wastewater management practices. These include economic constraints, lack of technical expertise, and resistance to changes in existing operational systems. Therefore, a comprehensive approach that integrates risk assessment, green productivity, and continuous monitoring is आवश्यक to achieve optimal environmental performance.

In summary, the literature indicates that integrating semi-quantitative environmental risk assessment with Green Productivity principles provides an effective framework for improving wastewater management. This approach enables industries to identify risks, prioritize solutions, and implement sustainable practices that balance economic and environmental objectives.

METHOD

This research was conducted at the coconut processing industry PT Nata de Coco X in Lampung Province in January 2024. The sequence of procedures carried out in this study is shown in the following figure.

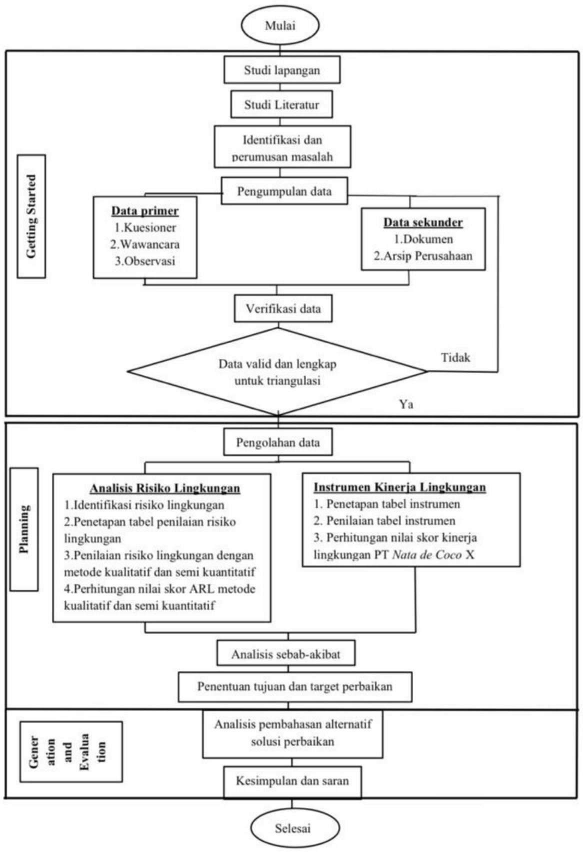

Figure. Flowchart

A. Data Collection

Several methods were used to collect data in this study, including:

1. Primary

a. Interviews

Interviews were conducted with five expert judges: the Secretary of the Environmental Division, Environmental Staff, Head of the Environmental Division, Quality Control Staff, and Production Manager.

b. Questionnaire

The purpose of this questionnaire was to obtain data and assessments from company employees. Before being distributed to the expert judges, the questionnaire was tested for validity and reliability regarding readability against the Draft Environmental Risk Analysis Questionnaire and Environmental Performance Instrument to determine whether it could be distributed to expert judges.

c. Field Observation

This method involves collecting data through direct observation or review in the field or areas requiring improvement. For the environmental risk analysis, observations were made regarding production processes, support facilities, utilities, and wastewater treatment plants (WWTP), including observations of environmental conditions, floors, wastewater distribution, technology used, and water and air pollution risks. Meanwhile, for field observations related to environmental performance, assessment aspects were used, which were assessed based on their suitability based on observations.

2. Secondary

The author used library research as a data collection method.

B. Environmental Risk Analysis

1. Risk Identification

This study identified risks and hazards based on a preliminary study and literature review conducted by the researcher. This study identified environmental risks related to the liquid waste produced by PT Nata de Coco X, from the source to the final wastewater treatment stage. This study aimed to identify areas in the process that require productivity improvements. Results showed that the production, support, utilities, and wastewater treatment plant (WWTP) processes have environmental impacts in the form of water and air pollution.

2. Risk Assessment

This study identified risks and hazards based on a preliminary study and literature review conducted by the researcher. This study identified environmental risks related to the liquid waste produced by PT Nata de Coco X, from the source to the final wastewater treatment stage. This study aimed to identify areas in the process that require productivity improvements.

C. Qualitative Data Processing Methods

Table. Risk Probability Matrix [6] [7] [8]

Level	Chance of Risk Occurring	Description
A	Almost Certain to Happen	The activity is estimated to almost certainly pose a risk to the surrounding environment. This is the highest rating.
B	Most likely	The activities carried out are estimated to have a high probability of causing risks to the surrounding environment. This is a high risk rating.
C	Medium Possibility	The activities carried out are estimated to have a moderate risk to the surrounding environment. This is a moderate rating.
D	Less likely	The activities carried out are estimated to have a small risk to the surrounding environment. This is a low risk rating.
E	Seldom	The activities carried out are estimated to pose little or no risk to the surrounding environment. This is a low risk rating.

Table. Risk Magnitude Matrix [6] [7] [8]

Level	Likelihood of Risk Occurrence	Description
1	Insignificant Impact	The activities carried out are expected to have an insignificant impact on the surrounding environment. This represents a low rating.
2	Minor Impact	The activities carried out are expected to have a minor impact on the surrounding environment. This represents a low-level rating.
3	Moderate Impact	The activities carried out are expected to have a moderate impact on the surrounding environment. This represents a medium rating.
4	Major Impact	The activities carried out are expected to have a major impact on the surrounding environment. This represents the second-highest rating.
5	Very Major Impact (Disaster)	The activities carried out are expected to have a very significant impact or may cause a disaster to the surrounding environment. This represents the highest rating.

A qualitative risk assessment of the likelihood of a risk occurring and its magnitude, ranked based on the severity of the impact. The hierarchy of risk magnitude and probability can be seen in the following table.

Table. Hierarchy of Quantity and Risk Probability of Qualitative Methods

Chance of Risk Occurring (Possibility)	Risk Magnitude (Impact/Consequences)					
		1	**2**	**3**	**4**	**5**
	A (5)	R	S	M	B	T
	B (4)	R	S	M	B	T
	C (3)	R	S	S	M	M
	D (2)	R	R	S	S	S
	E (1)	R	R	R	R	R

Description
R = Low, S = Moderate, M = Medium, B = Significant, T = High

Next, the average score of the risk results is calculated and then classified. The following is the scale used by the author to determine the hierarchy in the following table:

Table. Range of Scale Description Environmental Risk Qualitative Method

Range	Risk Description
1-5	Low
5,1-10	Moderate
10,1-15	Intermediate
15,1-20	Significant
20,5-25	High

D. Semi-Quantitative Data Processing

The following table shows the frequency, magnitude, and sensitivity levels of incidents.

Table. Tabulation of Frequency Level of Events, Magnitude of Events and Sensitivity [6][7][8

Level	Description		
	Frequency of Occurrence (F)	**Magnitude of Impact (S1)**	**Sensitivity (S2)**
1	Unlikely to occur	No risk	Not a public concern
2	Low	Low risk and impact	Concern of a specific group
3	Medium	Moderate risk	Regional concern
4	Frequent occurrence	High risk	National concern
5	Very frequent occurrence	Very high risk	International/global/media concern

To calculate the risk recapitulation using the semi-quantitative method, use the following equation:
$R=F \times (S1+S2)$ (3.1)

Description
R = Risk, F = Frequency of Event, S1 = Magnitude of Event, S2 = Sensitivity
Before classifying the category range, the average score of the risk results is calculated. The final risk magnitude is then classified using a semi-quantitative method. This is then classified into the following ranges.

Semi-Quantitative Method Risk Category Table

Risk Category	Range
Low Risk	0–250
Moderate Risk	251–500
High Risk	501–750

E. Environmental Performance Analysis

In this study, corporate environmental performance was measured using a validated and tested Environmental Performance Instrument. The objective was to evaluate corporate environmental performance and identify improvements using a Green Productivity approach.

No.	Assessment Aspect	Criteria	Objective	Reference
1	Compliance with Environmental Quality Standards	Wastewater	To ensure that the 8 wastewater parameters produced by PT Nata de Coco X meet environmental quality standards. The 8 parameters are: • pH • BOD • COD • TSS • Oil & Grease • Ammonia • Total Coliform • and Discharge	[7]
2	Wastewater Treatment Facilities	WWTP (IPAL) operation (in accordance with applicable requirements)	To ensure that all WWTP units of PT Nata de Coco X operate properly, so that wastewater can be treated correctly before discharge. There are 7 types of wastewater treatment ponds: • Inlet • Stabilization • Anaerobic • Aeration • Aerobic • Indicator • and Outlet	[7]
3	Compliance with Permits	Conducting wastewater discharge to water bodies/sea/formation through	To ensure that wastewater discharge complies with the permit requirements issued by the authorities, in order to maintain compliance with	[8]

		injection/utilization to land in accordance with permit provisions	environmental regulations	
4	Compliance with Compliance Points and/or Monitoring Points	Conducting routine monitoring at all compliance points and/or monitoring points in accordance with requirements stated in permits and/or regulations	To ensure compliance at all required monitoring locations and compliance points, in accordance with permit requirements and regulations	[8]
5	Compliance with Data Quantity for Each Parameter	Reporting monitoring data for each parameter at every compliance point and/or monitoring point periodically in accordance with permit and/or regulatory requirements	To ensure transparency and monitor wastewater quality	[8]

Weighting

The instrument's weighting uses a Likert scale with four intervals. The weighting is then categorized by positive statements, as shown in the following table.

Table of Scores for Each Weight of Environmental Performance Instruments

Category	Score
Always	4
Often	3
Sometimes	2
Never	1

To conduct a triangulation analysis discussion per statement, the author created an average score range based on the number of expert judgments, using the following formula:

$$\text{Statement}=\frac{\text{Total } \textit{expert judgement}}{5}$$

Furthermore, the scores are categorized into score ranges per environmental performance instrument statement, which can be seen in the following table.

Environmental Performance Instrument Weighting Score Table Per-Statement

Score Range	Category
4	Always
3–3.9	Often
2–2.9	Sometimes
1–1.9	Never

F. Data Processing

The data obtained from the questionnaire was processed using Microsoft Excel. The scores given by the expert judges for each statement were summed for each expert judgement, then converted to a percentage (% score) according to the following formula:

$$P = \frac{\text{Total } \textit{expert judgement}}{\text{Total Ideal Score}} \times 100\%$$

Description:

The ideal score is the desired number of 180. This number is obtained from adding up the highest total scores from the five expert judgments.

G. Data Analysis

Data analysis was conducted as follows:

a) Calculation of the average score

This average expert judgment score was calculated as a measure of data centrality.

b) Classification of Results

The research results were categorized based on the average score according to the criteria table. The criteria table for the results categories is as follows:

Value Range Category Classification Table

Category	Percentage Range
Very Good	76–100%
Good	51–75%
Poor	26–50%
Very Poor	0–25%

H. Triangulation Analysis

In this study, a triangulation method was used to test the validity of the data. Data validity was achieved through the use of triangulation techniques in the data collection process, including questionnaires, observations, and interviews [9].

I. Developing Alternative Green Productivity Solutions

a. Cause-and-Effect Analysis

To analyze the causes and effects based on the results of the environmental risk analysis and environmental performance that require improvement.

b. 5W1H (What, Where, Who, When, Why, and How)

To describe the five causal factors in the Ishikawa diagram in detail.

c. Determining Solution Priorities

Priority determination is carried out by assessing each alternative solution proposed by the researcher using expert judgment.

Technical and Environmental Aspects Assessment Scale Table

Aspect	Weight Score	Description
Technical	3	Very easy to implement, including ease in technology and application, procurement of materials, and human resources

	2	Easy to implement and apply, but there are still some technical constraints
	1	Difficult to implement, due to factors such as technology or materials that must be imported, etc.
Environmental	3	Provides significant positive effects and benefits to the environment
	2	Provides minor positive effects and benefits to the environment
	1	Provides no positive effects or benefits to the environment

RESULTS AND DISCUSSION

A. Environmental Risk Assessment Of Liquid Waste

1. Qualitative Method

Environmental risk analysis using the qualitative method uses an analytical approach for each process to identify the potential environmental risks of each process.

— **Production**

ARL Results Table of Qualitative Method of Production Process

PRODUCTION PROCESS			Expert Judgment Assessment						
No.	**Nata de Coco Production Work Unit**	**Environmental Impact**	**EJ-01**	**EJ-02**	**EJ-03**	**EJ-04**	**EJ-05**	**Average Score**	**Description**
1	Soaking Nata de Coco I	Water pollution	2	2	2	2	2	10/5 = 2	Low
2	Boiling Nata de Coco I	Air pollution (odor)	2	2	2	2	2	10/5 = 2	Low
3	Soaking Nata de Coco II		2	2	2	2	2	10/5 = 2	Low
4	Soaking Nata de Coco III		2	2	2	2	2	10/5 = 2	Low
5	Boiling Nata de Coco II		2	2	2	2	2	10/5 = 2	Low

— **Supporter**

ARL Results Table of Qualitative Methods of Supporting Process

No.	**Supporting Process**	**Environmental Impact**	Expert Judgment Assessment					**Average Score**	**Description**
			EJ-01	**EJ-02**	**EJ-03**	**EJ-04**	**EJ-05**		
1	Packaging Washing and Sanitation	Water pollution and air pollution (odor)	6	6	6	2	6	26/5 = 5.2	Moderate

2	Equipment and Room	–	2	2	2	2	2	10/5 = 2	Low

— **Utility**

ARL Results Table of Qualitative Method of Utility Process

No.	Utility	Environmental Impact	Expert Judgment Assessment					Average Score	Description
			EJ-01	EJ-02	EJ-03	EJ-04	EJ-05		
1	Boiler	Water pollution	6	6	6	6	6	30/5 = 6	Moderate

— **IPAL**

ARL Results Table of Qualitative Method of WWTP Process

PRODUCTION PROCESS		Environmental Impact	Expert Judgment Assessment					Average Score	Description
Nata de Coco Production Work Unit			EJ-01	EJ-02	EJ-03	EJ-04	EJ-05		
1	Inlet Pond	Water pollution and air pollution (odor)	12	6	12	6	12	48/5 = 9.6	Moderate
2	Stabilization Pond		6	6	6	6	6	30/5 = 6	Moderate
3	Anaerobic Pond		6	6	6	6	6	30/5 = 6	Moderate
4	Aeration Pond		6	6	6	6	6	30/5 = 6	Moderate
5	Aerobic Pond		6	6	6	6	6	30/5 = 6	Moderate
6	Indicator Pond		6	6	6	6	6	30/5 = 6	Moderate
7	Outlet Pond		6	6	6	6	6	30/5 = 6	Moderate

2. Semi-Quantitative Method

Environmental risk analysis using qualitative methods uses an analytical approach for each process to identify the potential environmental risks of each process.

Semi-Quantitative Method ARL Assessment Results Table

Category	Expert Judgment Assessment					Total
	EJ-01	EJ-02	EJ-03	EJ-04	EJ-05	
Production	15	20	15	30	15	95
Supporting	9	8	9	8	9	43
Utilities	8	3	8	3	8	30
WWTP (IPAL)	84	45	84	45	84	342
Total Risk Weight						**510**
Average						**127.5**

3. Triangulation Analysis

- Production Process

Based on questionnaires, observations, and interviews, interrelated findings emerged. The author concluded that the environmental risk associated with liquid waste from the soaking and boiling of nata de coco is relatively low. This is due to the production process's closed drainage system, which minimizes spills during wastewater distribution and the risk of environmental pollution.

B. Environmental Performance

Summary Table of Environmental Performance Assessment of PT Nata de Coco X Wastewater

Expert Judgement	**Statement**									**Total**
	P01	**P02**	**P03**	**P04**	**P05**	**P06**	**P07**	**P08**	**P09**	
EJ-01	4	3	4	4	4	4	4	4	3	34
EJ-02	3	3	4	4	4	3	4	4	3	32
EJ-03	4	3	4	4	4	4	4	4	4	35
EJ-04	4	4	4	4	4	4	4	4	3	35
EJ-05	4	3	4	4	4	3	4	4	4	34
Averagescore	3,8	3,2	4	4	4	3,6	4	4	3,4	
Results category	Often	Often	Always	Always	Always	Often	Always	Always	Often	
Grand Total										170
P = Total score obtained / 180 (ideal score) × 100% = 94.4%										94.4 %

Description

P01-P09 = Statements 01-09, P = Final Environmental Performance Score, EJ = Expert Judgment. The company's overall environmental performance related to its liquid waste was 94.4, categorized as very good. This is because PT Nata de Coco X's environmental performance is already relatively good, but there are several elements that can be improved to achieve more effective and efficient results.

C. Triangulation Analysis

Based on triangulation analysis conducted by researchers using three different testing methods, the results of the three tests demonstrated consistency and interconnectedness, providing validity to the research findings. Therefore, because the findings from the various testing methods mutually support each other, the research is considered valid in the context of using a triangulation approach to the company's environmental performance in liquid waste. For environmental quality standards, the study received a frequent category because the debut parameter exceeded the IPLC quality standard limit. For liquid waste management facilities, the study received a frequent category because the sludge drying bed pond and indicator pond were no longer operational. For technical provisions, the wastewater drainage system received a frequent category because it did not comply with liquid waste disposal procedures due to a liquid waste spill. For wastewater management, the study received a frequent category because the wastewater had not been classified as reusable.Green Productivity Concept Strategy.

D. Green Productivity Concept Strategy

a. Fishbone Diagram

Based on the cause-and-effect analysis reviewed by the author, the primary problem is "Decreased Environmental Performance Efficiency in the Liquid Waste Aspect." The analysis of the cause-and-effect relationship between environmental risk analysis and environmental performance shows that the results of the environmental risk analysis influence how efforts to improve environmental performance are implemented, while improved environmental performance can help mitigate environmental risks. This is also stated in research [10], which states that effective environmental performance is needed to reduce the risk of environmental pollution and fulfill the company's obligation to protect its environment.

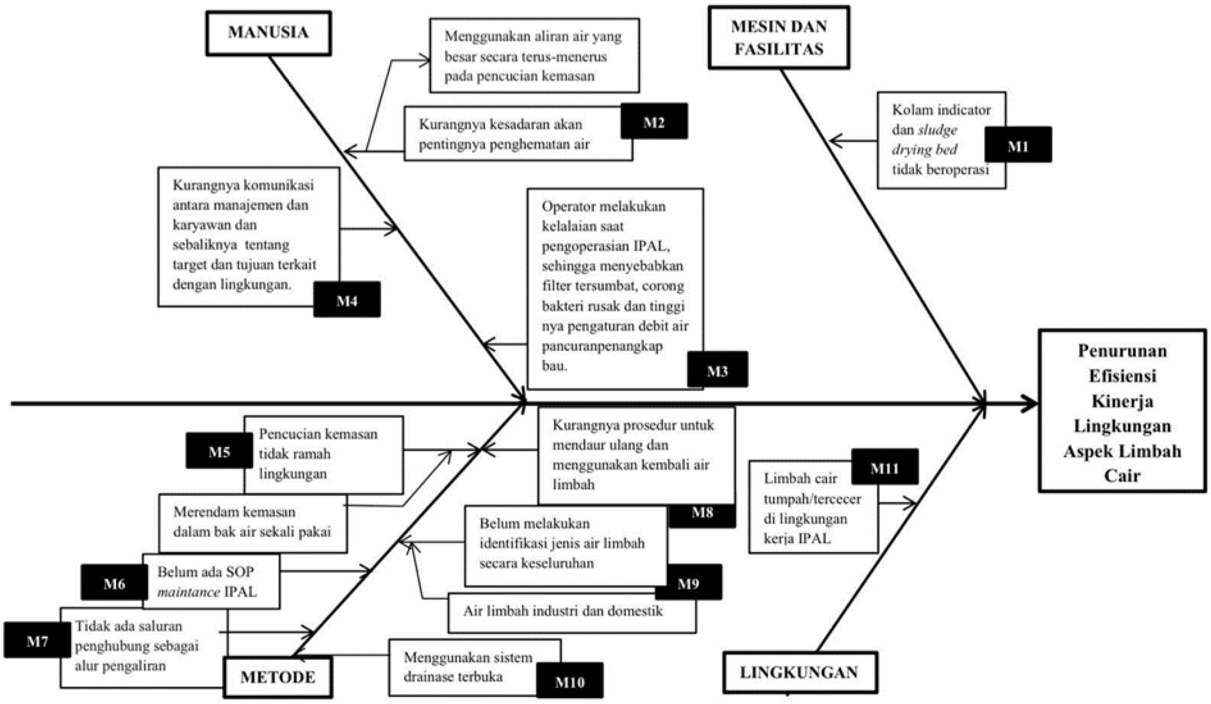

Figure: Fishbone Diagram

E. Solution Development

- **Machinery and Facilities**

  Routine maintenance of the WWTP, especially the sludge drying bed pond, and installation of physical barriers such as nets or fences around the indicator pond.

  Technical: Routine maintenance of the WWTP is carried out daily, especially on the sludge drying bed pond, which is overgrown with weeds due to lack of maintenance. To address this, routine monthly draining and maintenance is recommended. The indicator pond is neglected because the indicator fish are eaten by monitor lizards, causing excessive sludge accumulation. It is recommended to install physical barriers such as nets or fences around the pond to prevent predator access, with stakes to strengthen the net structure.

  Environmental: The Sludge Drying Bed (SDB) dries and disinfects sludge using sunlight. SDB maintenance improves the WWTP's working environment, converting sludge into a cake that is safe for disposal or use, and reducing sludge accumulation. The indicator pond tests effluent quality with fish. Re-operating the SDB improves WWTP performance and green industry value, enhancing the company's reputation among consumers, investors, and the community.

- **Human**

  Training for all employees on the importance of water conservation.

  Technical: Water conservation training for employees, led by skilled facilitators, with discussions, case studies, and demonstrations.

  Environmental: This training aims to reduce the environmental impacts of excessive water use, such as depletion of water reserves and decreased water quality. Employees will learn to reduce water consumption, increase resource efficiency, and reduce company operational costs, support environmental sustainability, and improve financial performance.

— Distribute information regularly through various internal company communication channels.

Technical: Develop a schedule and information materials to be distributed to employees. This information can then be disseminated through various internal communication channels, such as bulletin boards in public areas or offices, email, or company email. Environmental: By having easy and continuous access to information on water conservation, employees can continue to practice environmentally friendly behaviors.

- Conduct evaluation findings for operators and employees.
  Technical: Establish an evaluation schedule, and then have the evaluation team examine various aspects of WWTP maintenance, including employee reporting. The team will review compliance with procedures, reporting quality, and operator performance, document the results, and provide recommendations for improvements or additional training.

  Environmental: This evaluation identifies areas requiring improvement or additional training, improves operator performance, and reduces environmental risks.

- **Method**
  Replacing single-use water tanks with a circulating water washing system. Technical: Installation is carried out according to the company's needs and testing of the new system to ensure its operation is as expected. Once the system is installed, employees are trained to use the new washing system efficiently and effectively. Periodic monitoring and evaluation are also conducted throughout the implementation process.
  Environmental: Replacing single-use water tanks with a continuous washing system such as a water blancher can save water and energy and remove contaminants through blanching.

- Developing a Wastewater Treatment Plant Maintenance Standard Operating Procedure (SOP)
  Technical: Begin by identifying needs and objectives and involve a team of environmental experts, technicians, and managers for a thorough analysis. The team designs a basic SOP framework that includes objectives, policies, routine steps, emergency procedures, maintenance, and reporting of monitoring results. This process involves consulting with experts and takes into account factors such as occupational safety, environmental sustainability, and resource availability. Once the framework is developed, validation and adjustments are carried out through trials, identifying problems, and adjusting the SOP based on feedback.

  Environmental: Implementing this SOP maintains environmental sustainability, reduces negative impacts on the ecosystem, and supports overall sustainability.

- Install pipes/hoses for appropriate wastewater drainage.
  Technical: Determine the optimal route for these new pipes, select the appropriate type of pipe/hose, and monitor the performance of this new drainage system to ensure there are no leaks or other problems.

  Environmental: Ensure smooth and efficient wastewater flow.

- Utilize Nata de Coco liquid waste into Liquid Organic Fertilizer
  Technical: The company will collect liquid waste from Nata de Coco production and process it into liquid organic fertilizer through fermentation, pH adjustment, bioactivator addition, and temperature control. Tea dregs as a bioactivator are proposed because they are more effective than eggshells in meeting the technical standards for Organic C-POC, as well as improving soil fertility and plant growth. After fermentation, the liquid organic fertilizer is filtered and packaged for use on the company's farms or gardens, reducing wastewater and providing environmental benefits.

  Environmental: Reducing wastewater and improving environmental sustainability

- Reusing condensate wastewater as boiler feed
  Technical: To implement this solution, the feedwater must meet the requirements for boiler water, free from substances that can damage the boiler. External and internal treatments such as pH control and water treatment are required to maintain water quality. Intensive laboratory research ensures the water

meets these requirements, helping to extend boiler life, reduce clean water consumption, and optimize company resources.

Environmental: Reducing the environmental impact caused by excessive clean water use
Utilizing wastewater from packaging washing, ablutions, and vegetable washing for plant watering

Technical: Wastewater from packaging washing, ablutions, and kitchens does not contain high levels of pollutants and can be used for plant watering. The first step is to collect the wastewater, then filter and treat it to ensure its safety. Using this wastewater for plant watering helps reduce clean water consumption and the burden on the wastewater treatment plant (WWTP).
Environmental: Can reduce clean water consumption and the burden on the wastewater treatment system. This greywater, which does not contain high levels of pollutants, can be safely used for plant watering, helping to reduce the negative impact on the environment.

- Increase the frequency and volume of wastewater recycling.
  Technical: Based on in-depth interviews, PT Nata de Coco X has been operating and testing a recycling plant since July 2023, with a capacity of 120,000 liters and a trial use of 50,000-60,000 liters of wastewater per week. The recycled water is used for cleaning employee equipment. The author recommends increasing the volume of recycled wastewater and the operating frequency to three times a week, and suggests daily recycling to reduce clean water use and support the company's CSR by providing recycled water to local residents.

  Environmental: Implementing a wastewater recycling plant at PT Nata de Coco X can reduce clean water consumption and provide significant environmental benefits. By increasing the volume and frequency of recycling, the company can use recycled water for other purposes such as plant watering and cleaning rooms, and support its corporate social responsibility (CSR) by providing recycled water to the surrounding community, although this requires additional investment in human resources and operations.

- Creating a water balance
  Technical: The first step in a company's operational audit is to identify industrial and domestic wastewater sources and analyze water usage and flow within those processes. This data is organized and Calculated to determine the difference between inflow and outflow, helping to understand water usage patterns, identify potential efficiencies, and develop more sustainable water management strategies.

  Environmental: Helps understand water usage patterns, identify potential efficiencies, develop water management strategies, reduce clean water consumption, minimize wastewater discharge, and support sustainable business practices.

- Replacing an open wastewater drainage system with a closed system to prevent wastewater spills.
  Technical: The first step in replacing an open drainage system with a closed one is to conduct an evaluation and planning, followed by dismantling the old system and preparing the area for the new system's installation. After installing the pipes and additional equipment, the new system is tested and monitored to ensure proper functionality, reduce the risk of wastewater spills, and improve waste management efficiency.

  Environmental: Replacing an open drainage system with a closed one through evaluation, planning, dismantling, installation, testing, and monitoring can reduce the risk of wastewater spills, prevent environmental pollution, improve waste management efficiency, optimize water resource use, and maintain environmental sustainability and the quality of aquatic ecosystems.
  Environment
- Creating an Emergency Response SOP for Wastewater Treatment Plants
  Technical: The first step in conducting routine inspections and developing an emergency SOP for handling wastewater spills is to establish a regular inspection schedule and assess the potential risks of a

spill. Based on the inspection results, a clear and detailed emergency SOP is created, disseminated to all personnel, and training is conducted to ensure a good understanding of the procedures to be followed.

Environment: Can reduce the impact of environmental pollution and ecosystem damage caused by wastewater spills

F. Solution Priority

Table. Solution Priority Assessment

No.	Green Productivity Solution Options	Evaluation		
		Technical	Environmental	Total
1	Routine maintenance of the WWTP (IPAL), especially the sludge drying bed, and installation of physical barriers such as nets or fences around the indicator pond	2	3	5
2	Training for all employees on the importance of water conservation	3	2	5
3	Disseminating information regularly through various internal company communication channels, such as notice boards	3	2	5
4	Conducting evaluation meetings with operators	2	2	4
5	Replacing single-use water tanks with a washing system that uses water circulation	1	3	4
6	D+D13:D21eveloping SOP for WWTP (IPAL) maintenance	3	2	5
7	Installing pipes/hoses as proper wastewater flow channels	1	1	2
8	Utilizing Nata de Coco wastewater into liquid organic fertilizer	1	3	4
9	Reusing condensate wastewater as boiler feed water	2	3	5
10	Reusing wastewater from packaging washing, ablution, and vegetable washing for plant irrigation	3	3	6
11	Increasing wastewater recycling capacity	2	3	5
12	Creating a water balance system	2	2	4
13	Replacing open wastewater distribution system with a closed system to prevent spills	1	3	4
14	Developing emergency response SOP for WWTP (IPAL)	3	2	5

The following is a description of the solution priorities:

a. The first priority for implementing green productivity solutions is solution number 10.
b. The second priority for implementing green productivity solutions is solutions number 1, 2, 3, 6, 9, 11, and 14.
c. The third priority for implementing green productivity solutions is solutions number 4, 5, 8, 12, and 13.
d. The fourth priority for implementing green productivity solutions is solution number 7.

In the expert judgment, the company expressed reluctance to change its infrastructure due to the associated economic considerations and potential disruption to operations. However, the company openly accepted the possibility of system changes that could provide long-term benefits, even if they would require adjustments in implementation and management.

CONCLUSION

The following conclusions can be drawn from this study: The environmental risk analysis used data triangulation (questionnaires, observations, and interviews). The results of the environmental risk analysis based on qualitative methods showed that 5 production processes were classified as low risk, 1 supporting process was categorized as low and medium, the boiler process was categorized as medium, and 7 wastewater treatment plants were categorized as medium risk. The semi-quantitative method showed a total environmental risk of 102, also classified as low risk.

Observation and interview results supported these findings, demonstrating consistency with the questionnaire assessment. Analysis of PT Nata de Coco X's environmental wastewater performance using data triangulation showed a questionnaire score of 94.4, categorized as very good, although improvement is needed. Observations and interviews supported the questionnaire results, demonstrating the consistency and validity of the study. Based on a cause-and-effect analysis using a fishbone diagram, 4 factors with 11 causes were identified. A 5W1H analysis was then conducted to identify solutions, which were analyzed based on technical and environmental aspects to determine solution priorities. One first-priority solution was identified, utilizing wastewater from packaging washing, ablution, and vegetable washing for plant watering. Seven second-priority solutions, five third-priority solutions, and one final priority solution, installing pipes/hoses for wastewater drainage.

The following recommendations can be made based on the results of this study: For further research, an in-depth analysis of economic feasibility is needed to obtain more accurate solution priorities. A company material balance is required to facilitate accurate analysis of wastewater flow, rather than simply using percentages to ensure unbiased results. In Fishbone Diagram analysis, careful attention to the cause-and-effect structure is crucial, as it will influence strategy development.

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