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Analysis of Water Balance and Water Treatment Process in Water Control for Environmental Performance Assessment: Case Study at WTP Plant PT XYZ Jakarta, Indonesia

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Abstract

This study is focused on analyzing the water balance and water treatment process at the Water Treatment Plant (WTP) PT XYZ, with a specific emphasis on the Environmental Performance Assessment Program (PROPER KLHK). Employing an ex post facto experimental method with a 2x2 factorial design, the study seeks to evaluate how water management methods and managerial skills impact environmental performance. Through field observations, interviews, questionnaires, and analysis of documents and WTP technical reports, the data collection process was comprehensive. The results underscore the significant influence of the interaction between water management methods and managerial skills on WTP environmental performance. Additionally, the study identifies key areas for improvement and offers recommendations to bolster the sustainability of water management at PT XYZ. These insights serve as a valuable roadmap for the development of more efficacious and environmentally responsible water management strategies in the future.

Keywords: Water control, Water Balance Analysis, Water Treatment Process, Environmental Performance Assessment Program (PROPER KLHK), Experimental Ex Post Facto

1. Introduction

Amidst rapid global development, the availability of clean and drinkable water has become a crucial issue that cannot be ignored by many countries, including Indonesia (Limuris, 2021). Along with population growth, urbanization, and increased industrial activity, the need for clean water continues to grow (Anisyaturrobiah, 2021). The soap industry, as an integral part of the manufacturing sector, has a major contribution to people's daily needs (Pratama & Projo, 2024). However, its production process often causes significant water pollution. Although there are various regulations and environmental management programs, there are still gaps in implementing sustainable practices (Engert & Baumgartner, 2016). The rapid development of soap production technology has not been balanced by efforts to manage water efficiently, often causing pollution and negative environmental impacts. This study focuses on the analysis of water balance and water treatment process at WTP PT XYZ. Water balance is an important method for identifying and evaluating the sources and uses of water in the system, becoming the basis for decision making for efficient and sustainable water management (Arif et al., 2023). The water treatment process

involves a series of water treatment stages to ensure water quality meets health and environmental standards. The main problem faced by WTP PT XYZ is how to ensure efficiency and effectiveness in water management, both in terms of quantity and quality. The imbalance between incoming water discharge and WTP processing capacity and the varying quality of raw water are major challenges (Putri & Purwanti, 2019).

In the context of regulation, Indonesia has various laws and regulations that support environmental and water resource management. Some of them are Law No. 32 of 2009 concerning Environmental Protection and Management, Law No. 18 of 2008 concerning Waste Management, and PP No. 101 of 2014 concerning Wastewater Management. The Company Performance Rating Assessment Program in Environmental Management (PROPER) by the Ministry of Environment and Forestry is one of the important instruments to measure company compliance with established environmental standards.

This study uses an ex post facto experimental method with a 2x2 factorial design to evaluate how water balance efficiency and water treatment process quality affect environmental performance at WTP PT XYZ (Sappaile, 2010). The results of this study are expected to provide a significant contribution to improving the environmental performance of WTP PT XYZ and become a model that can be adopted by other water treatment facilities in Indonesia.

This study aims to answer several crucial problems related to environmental management in the soap industry, especially related to water pollution control for the Environmental Performance Assessment (PROPER KLHK) at WTP Plant PT XYZ. The following are the formulations of the problems that will be answered through this study:

1. How is the current water planning and management system at WTP PT XYZ?
2. How is the water quality control process implemented at WTP PT XYZ?
3. How is water balance analysis carried out to identify water waste points at WTP PT XYZ?

By considering these questions, this study is designed to explore in-depth and comprehensive information, which will help in answering the research hypothesis as well as provide useful insights for system improvement and optimization at WTP PT XYZ.

2. Research variable

Water balance describes the balance between water input and output in a system, essential for water resource management and environmental planning. Water balance involves comparing water input (rainfall, external sources) with water output (evaporation, outflow) and changes in water storage. It helps manage water availability, especially in areas prone to drought or flooding. The analysis includes rainfall, evaporation, surface runoff, and groundwater percolation. In the study at WTP Plant PT. XYZ, the volume of inflow and outflow was analyzed to map the sources and volume of liquid waste. Water regulation includes water input (rainfall, river flow, wells), water use (industry, agriculture, household, environment), water output (wastewater, domestic water), and balance and management (reducing waste, managing wastewater, and rainwater collection). Research related to water use efficiency in the soap industry shows areas of waste and efficient practices, evaluation of water management systems, and implementation of water recycling. PT. XYZ uses PDAM water. The water treatment process involves initial screening, coagulation, flocculation, filtration, and disinfection to improve water quality. Water Treatment Plant (WTP) PT XYZ, has two WTPs for processing liquid waste from production. Water control involves steps to ensure efficient water use and waste management according to regulations. Water quality in the detergent industry is important to ensure optimal production and minimize negative impacts on the

environment. The water quality parameters of the soap industry include BOD, COD, TSS, and MBAS. Monitoring these parameters is important for the production of high-quality detergents and wastewater management. Environmental performance assessment is the evaluation of the impact of industry on the environment to improve sustainable management, with indicators such as waste emission levels, resource efficiency, and compliance with environmental regulations.

3. Research Method

The method used to conduct this research is the Ex Post Facto method. According to Putrawan, the Ex Post facto method is used to research whether or not the independent variable affects the dependent variable through measurements of events that have already taken place but are viewed in the context of the current time without manipulating the variables being studied.

The events that have occurred that are measured in this study include 1) Surfactant / MBS levels in the air control process at the WTP Plant; 2) Application of air control methods through water treatment technology and water balance technology operated by operators from PT XYZ as the main effect; and 3) Managerial skills of the liquid waste processing operator manager. The water treatment quality standards were measured by the PT XYZ laboratory (TSS, MBAS, COD, Ammonia, Phosphate, PH) and external laboratories (Total Coliform, Oil and Fat).

Based on the description of the research variables above, the results of the study were analyzed using an Ex Post Facto research design with a level of 2 X 2. The data in this study can be explained as the values in the design :

1. Surfactant / MBS content value in water balance technology with high skills (A1B1).
2. Surfactant / MBS content value in water treatment analysis with high managerial skills (A2B1).
3. Surfactant / MBS content value in water balance Plant technology with low managerial skills (A1B2).
4. Surfactant / MBS content value in water treatment analysis with low managerial skills (A2B2).

This study for hypothesis testing was analyzed using an Ex Post Facto research design level 2 X 2 which can be interpreted as follows:

Managerial Skill	Water Control Method	
	Technology Water balance analysis A_1	Technology water treatment process A_2
High Managerial Skill (B_1)	A_1B_1 >	A_2B_1
Low Managerial Skill (B_2)	A_1B_2 >	A_2B_2

Table 1 Ex Post Facto Design by Level 2 X 2

4. Population and Sample

The accessible population in this study were 43 employees of the liquid waste processing operations department of PT XYZ, each of whom was taken randomly. From the respondents who had answered the managerial skills measurement instrument after being arranged based on the highest to lowest ranking, samples were taken to fulfill the variable categories of high managerial skills (top ranking) and low managerial skills (bottom ranking). Errors in determining the population can cause the collected data to be inaccurate, so that the research results are of poor quality, not representative, and cannot be generalized properly (Amin et al., 2023). Determination of the number of samples using the Slovin formula, The sample is calculated using the Slovin technique according to Sugiyono, 2011 The Slovin formula for determining the sample is as follows:

$$n = \frac{N}{1+N(e)^2}$$

$$= \frac{43}{1+43(0,2)^2} = 15,8 \text{ sample}$$

Description:

n = sample size/number of respondents

N = population size

e = percentage of tolerance for sampling error accuracy In the Slovin formula there are the following provisions:

The value of e = 0.1 (10%) for a large population

The value of e = 0.2 (20%) for a small population

then the number of sample data analyzed for the upper or lower group is = 15.8; (set at 16 samples).

Data analysis with prerequisite analysis (normality and homogeneity test) and research analysis or hypothesis analysis used multi-way ANOVA analysis (two or more factors), especially for two-way ANOVA used for experimental research consisting of two independent variables by level. Finally continued with discussion, conclusions, implications, and suggestions. To test the research hypothesis and to draw conclusions, the data has been collected and analyzed using statistical techniques. The analysis used includes descriptive analysis, requirements analysis, and inferential analysis.

Testing the analysis prerequisites is very important in determining the right statistical method, whether using parametric or non-parametric tests. By conducting these prerequisite tests, it can ensure that the data meets the assumptions needed to use a particular statistical method so that the analysis becomes more valid and reliable (Usmadi, 2020). To find out whether there is an influence between water control through water balance analysis and water treatment process and managerial skills on reducing MBAS levels, the following statistical hypothesis was tested:

1. Ho : $\mu_{A1} = \mu_{A2}$
   H_1 : $\mu_{A1} > \mu_{A2}$
2. Ho : Int. A x B = 0
   H_1 : Int. A x B ≠ 0
3. Ho : $\mu_{A1B1} = \mu_{A2B1}$
   H_1 : $\mu_{A1B1} > \mu_{A2B1}$
4. Ho : $\mu_{A1B2} = \mu_{A2B2}$
   H_1 : $\mu_{A1B2} > \mu_{A2B2}$

5. Discussion of Research Results

1. Comparison of MBAS Level Reduction Methods:

- The average MBAS level reduction through Water Balance Analysis Technology and Water Treatment Process does not show a significant difference.
- MBAS level reduction is more effective with the right Water Treatment Process compared to just water balance analysis.
- Water balance analysis helps map production areas to identify pollution sources, while the Water Treatment Process focuses more on wastewater treatment.

2. Managerial Ability Factor:

- MBAS level reduction is not significant between the two methods when viewed as a whole, but managerial ability plays an important role.
- Managers with high technical, social, and conceptual skills can manage the process more effectively, which affects the results of MBAS level reduction.
- Internal regulations and batch operating systems in WTP plants can improve waste management efficiency.

3. Leadership Influence:

- Leadership with low managerial skills shows similar results between the two methods in MBAS level reduction.
- Leadership with high managerial skills can apply the method more effectively, both technically and ecologically, resulting in better MBAS level reduction.

4. Conclusion:

- The reduction of MBAS levels is more significant with the Water Treatment Process compared to water balance analysis, especially with high managerial skills.
- Leadership plays an important role in the implementation of water control methods, good managerial skills will provide more optimal results in waste management and reduce MBAS levels.

6. Conclusion

Based on the research results, conclusions, and implications that have been described above, the suggestions that can be conveyed in managing liquid waste:

1. Reducing the levels of MBAS and other chemical elements (BOD, COD, TSS, PH) by implementing water control methods with the water balance method (water balance analysis) and processing waste with a proper water treatment process and having high managerial skills.
2. There are improvement efforts from PT. XYZ to overcome MBAS levels, one of which is by adding an ozonation process after the water treatment process, from the existing samples showing a very significant impact on reducing MBAS levels.
3. Efforts to provide counseling, coaching, and training that have been started by PT. XYZ has helped all employees involved in it, from the manager level to the operator.
4. Internal regulations related to the quality and quantity of pollutants entering the WTP plant need to be realized immediately and changing the operating system from continuous to batching system can be more effective in controlling the reduction of MBAS levels.

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