EVALUATION OF WATER QUALITY MANAGEMENT IN ORGANIC FERTILIZER INDUSTRY: A CASE STUDY AT PT BIO MARAJA NUSANTARA MAKASSAR

EVALUASI PENGELOLAAN KUALITAS AIR PADA INDUSTRI PUPUK ORGANIK: STUDI KASUS DI PT BIO MARAJA NUSANTARA MAKASSAR

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Abstract

Management of water quality generated from the wastewater effluent of PT Bio Maraja Nusantara, a company that produces organic fertilizers in Makassar.. This fertilizer production activity produces liquid waste that has the potential to pollute the environment, especially local water quality. This study evaluates water quality based on Government Regulation No. 22 of 2021 concerning liquid waste management. Water quality testing measured physical, chemical, metal, and microbiological parameters. The results showed that the water quality met the quality standards set by the regulation, with the tested water not contaminated by hazardous materials such as odor, color, heavy metals, or pathogenic microorganisms. Analytical results showed the water had undetectable odor and color, low Total Dissolved Solids (TDS) content, and turbidity below the quality limit. In addition, the pH value, nitrate, nitrite, and hexavalent chrome content were also within safe limits. Microbiological testing showed the water was free from E. coli and coliform contamination. This study shows that effluent management efforts at PT Bio Maraja Nusantara effectively minimize negative impacts on local water quality and contribute to industrial water quality management literature in the sustainable agriculture sector.

Keywords: *Environment, Pollution, Quality Standard, Water Quality, Waste.*

Abstrak

Pengelolaan kualitas air dilakukan pada limbah cair buangan PT Bio Maraja Nusantara, yaitu perusahaan yang memproduksi pupuk organik di Makassar. Kegiatan produksi pupuk ini menghasilkan limbah cair yang berpotensi mencemari lingkungan, khususnya kualitas air setempat. Penelitian ini mengevaluasi kualitas air berdasarkan Peraturan Pemerintah No. 22 Tahun 2021 tentang pengelolaan limbah cair dan perlindungan lingkungan hidup. Pengujian kualitas air dilakukan dengan mengukur parameter fisika, kimia, logam, dan mikrobiologi. Hasil penelitian menunjukkan bahwa kualitas air memenuhi baku mutu yang ditetapkan oleh peraturan tersebut, yaitu air yang diuji tidak tercemar oleh bahan berbahaya seperti bau, warna, logam berat, maupun mikroorganisme patogen. Hasil analisis menunjukkan air memiliki bau dan warna yang tidak terdeteksi, kadar Total Dissolved Solids (TDS) rendah, dan kekeruhan di bawah batas baku mutu. Selain itu, nilai pH, kadar nitrat, nitrit, dan krom heksavalen juga berada dalam batas aman. Pengujian mikrobiologi menunjukkan air bebas dari cemaran E. coli dan coliform. Studi ini menunjukkan bahwa upaya pengelolaan limbah di PT Bio Maraja Nusantara secara efektif meminimalkan dampak negatif terhadap kualitas air setempat dan berkontribusi pada literatur pengelolaan kualitas air industri di sektor pertanian berkelanjutan.

Kata kunci: Kualitas Air, Limbah, Lingkungan, Pencemaran, Standar Mutu.

1. INTRODUCTION

Water is a natural resource that is very crucial for living things. The availability of clean water suitable for consumption is one of the leading indicators supporting public health (Putri & Yuniasih, 2022). However, along with population growth and industrial development, water quality in various sources such as rivers, lakes, wells, and groundwater has decreased significantly (Kustanto, 2020). Water can be polluted by domestic waste, agriculture (such as fertilizers and pesticides), industry, and mining activities(Farhan, et al., 2023). This contamination can lead to increased levels of contaminants in water, such as heavy metals, organic compounds, and pathogenic microorganisms that can harm human health and ecosystems (Mardhotila et al., 2024). Therefore, water quality management is essential to ensure the sustainability and safety of water resources (Avin & Lolo, 2023).

Water quality issues are also a concern in industrial activities, including at PT Bio Maraja Nusantara. The company produces organic fertilizers and is committed to developing sustainable agricultural solutions. The company is located in Parangloe Village, Tamalanrea District, Makassar City, South Sulawesi Province. In the production process, the company uses organic materials in the form of crop residues, animal manure, and other organic materials, which go through a series of production processes and testing to produce quality organic fertilizer. However, these activities also produce liquid waste on a large scale that has the potential to pollute the environment, especially the water quality around the production site.

This research is expected to add insight into water quality management in industrial environments, focusing on efforts to control pollution generated by the organic fertilizer production process. While many studies have addressed water quality in the context of industrial pollution, this research offers a new angle by integrating a case study on PT Bio Maraja Nusantara, a company committed to sustainable agriculture. In particular, it introduces a water quality evaluation effort based on Government Regulation No. 22 of 2021, intending to measure the effectiveness of wastewater treatment in minimizing negative impacts on local water quality. This provides a new contribution to the industrial water quality management literature, particularly in the agriculture and organic fertilizer sectors.

Although various studies examine the impact of industrial pollution on water quality, most studies focus on the impact of large industrial sectors such as manufacturing or mining (Kustanto, 2020; Farhan et al., 2023). However, few studies have explored how sustainable agriculture industries, particularly organic fertilizer production, affect local water quality through wastewater effluents. Furthermore, research on implementing government regulations, such as Government Regulation No. 22 of 2021, which regulates wastewater effluent management in the agricultural industry, is also limited. Therefore, there is a gap in research that links the evaluation of wastewater treatment with applicable environmental regulations and its application in the context of the organic fertilizer industry.

Therefore, Water pollution control through water quality assessment is crucial to ensure the sustainability of water resources and environmental safety. Through Government Regulation oNo. 22 of 2021 on Environmental Protection and Management, the Indonesian government has established clear guidelines for wastewater management, including water quality monitoring and liquid waste treatment. This research is urgently needed to assess the effectiveness of the implemented liquid waste treatment system and ensure that water returned to the environment is safe and does not contaminate natural resources. Additionally, proper water quality management will support the sustainability of water resources in the future, which is crucial given the increasing demand for clean water due to population growth and industrial development.

2. MATERIALS AND METHODS

This research was conducted by utilizing water samples taken from well water sources located in the operational area of PT Bio Maraja Nusantara.Well water quality testing was conducted based on physical, chemical, metal, and microbiological parameters to ensure clean water quality standards compliance. Each parameter is analyzed using standard methods verified and nationally recognized at the PT Global Quality Analytical Laboratory.

Physical parameters aim to identify the physical properties of water that can be observed directly or through measuring instruments. The five physical parameters tested include odor, color, total dissolved solids (TDS), turbidity, and temperature. Odor is analyzed using the organoleptic method through direct observation by the sense of smell to detect unnatural aromas in water samples (Triyastuti et al., 2024). This test is qualitative and relies on the sensitivity of the testing panel to water odor. Color testing is performed with a spectrophotometer on filtered water samples to obtain the actual color value in TCU (True Color Unit) units (Apriyanti et al., 2016; Handriyani et al., 2020). Total Dissolved Solids (TDS) was analyzed based on SNI 6989.27:2019. TDS measures the total amount of solids in dissolved form, which is calculated in mg/L using the gravimetric method (Mahmudah & Juliastuti, 2023). Turbidity was expressed in NTU (Nephelometric Turbidity Unit) and measured using a turbidimeter that detects light scattering by suspended particles (Nasriyanti, 2020). Temperature was measured according to SNI 06-6989.23:2005 using a thermometer.

Chemical parameter testing aims to identify the content of chemical compounds in water. The parameters tested included pH, nitrate (NO_3-N), nitrite (NO_2-N), and hexavalent chromium (Cr^{6+}). pH is a crucial indicator of water quality because it influences the solubility and availability of various elements. Water with excessively acidic pH levels or alkaline can lead to corrosion in piping systems, potentially releasing harmful metals like lead or copper into the water supply. The method described in SNI 6989.11:2019 for measuring pH involves calibrating a pH meter with standard buffer solutions to ensure accurate readings.(Ramadani et al., 2021). Nitrate (NO_3-N) was tested using the SNI 6989.79-2011 method using a spectrophotometer, while Nitrite (NO_2-N) was tested using the SNI 06-6989.9-2004 method using a spectrophotometer. Hexavalent Chromium (Cr^{6+}) was tested using the ASTM D1687-86 method.

Analysis of heavy metals in water aims to detect contamination of dissolved metal elements that can be toxic. The metal parameters tested were iron (Fe) and manganese (Mn). Both parameters were tested using the SNI 6989.84:2019 method through the Atomic Absorption Spectrophotometry (AAS) technique. For the detection of heavy metals such as iron (Fe) and manganese (Mn), Atomic Absorption Spectrophotometry (AAS) provides highly accurate measurements. In this method, a flame is used to atomize the water sample, and the metal atoms' absorption by light is measured. The amount of light absorbed at a specific wavelength corresponds to the concentration of the metal in the sample. AAS is highly sensitive and crucial for detecting low levels of toxic metals that can pose significant health risks.

Microbiological testing assesses the sanitary aspects and possible contamination of pathogenic microorganisms in water, particularly indicator bacteria such as *Escherichia coli* and Total Coliform. *E. coli* is tested using selective media to detect the presence of indicator fecal bacteria that indicate pollution from human or animal waste (Sitorus et al., 2024). Total Coliform Testing, conducted using membrane filtration techniques or the double tube method, involves filtering water through a membrane that captures bacteria, which are then cultured and counted. The results are expressed in Colony Forming Units (CFU) per 100 mL of water. The relationship between the number of colonies observed and water quality can provide valuable insights into the level of microbial contamination and help identify sources of pollution (Nugraheni et al., 2023).

3. RESULT AND DISCUSSION

Several water quality parameters are analyzed, including physics, chemistry, metals, and microbiology. Each parameter tested has a quality standard set by national or international standards. This discussion aims to review the analysis results against the quality standards used for each parameter tested and to assess whether the tested water quality meets the existing quality standards, based on the analysis results shown in Table 1.

Table 1. Water quality analysis

No.	Parameters	Results	Quality Standard	Unit	Methods
I	**PHYSICS**				
1	Smell	Odorless	Odorless	-	Organoleptic
2	Color	< 1.2	10	TCU	7.2/IK/GQA/WQ/046
3	Total Dissolved Solids	247	< 300	Mg/L	SNI 6989.27:2019
4	Turbidity	0.71	< 3	NTU	6.4/IK/GQA/027
5	Temperature	28.3	Air temperature ±3	-	SNI 06-6989.23:2005
II	**CHEMISTRY**				
1	pH	7.37	6.5 - 8.5	-	SNI 6989.11:2019
2	Nitrogen, Nitrate as N (NO_3-N)	0.119	20	Mg/L	
3	Nitrogen, Nitrite as N (NO_2-N)	< 0.002	3	Mg/L	SNI 06-6989.9-2004
4	Chrome, Hexavallen, Cr^{6+}	< 0.001	0.01	Mg/L	ASTM D1687-86
III	**METALS**				
1	Iron, Dissolved Fe	0.128	0.2	Mg/L	SNI 6989.84:2019 (AAS)
2	Manganese, Dissolved Mn	< 0.06	0.1	Mg/L	SNI 6989.84:2019 (AAS)
IV	**MICROBIOLOGY**				
1	E. Coli	0	0	CFU/100 mL	7.2/IK/GQA/MQ/021
2	Total Coliforms	0	0	CFU/100 mL	7.2/IK/GQA/MQ/021

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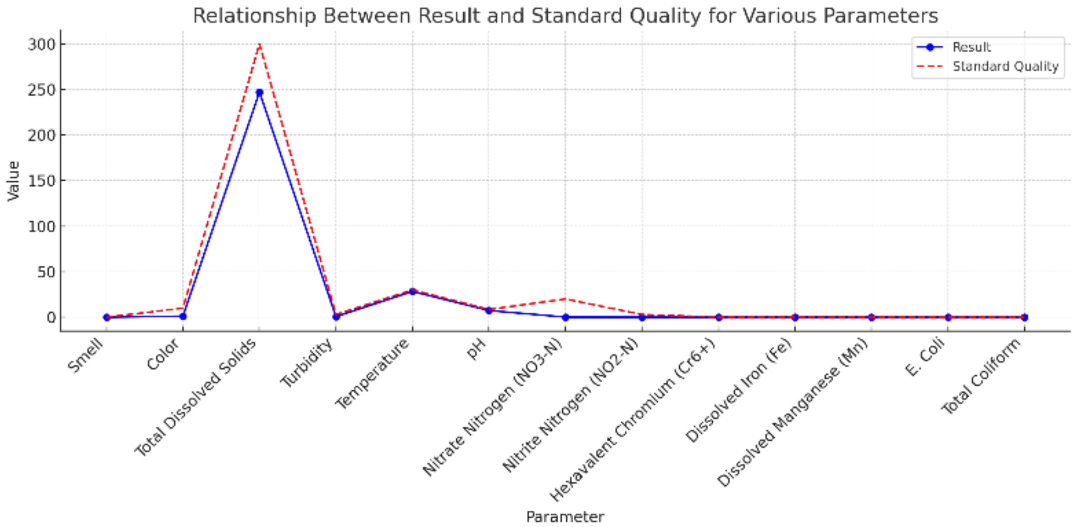

Figure 1. Relationship between analyzed values and quality standards for various parameters

The graph shows that parameters such as E. Coli and Total Coliform have a result of 0, which is within acceptable limits, indicating the absence of contamination. Other parameters, such as Total Dissolved Solids and Turbidity, are also within the allowable limits, indicating compliance with quality standards. pH, nitrogen levels, and hexavalent chrome are also within safe and regular values. Meanwhile, Temperature and Odor values met the prescribed conditions. This visualization helps assess whether the results for each parameter conform to the expected quality standards, highlighting areas where the measured values are within or exceed acceptable limits.

The analysis showed that the water was odorless, per the quality standard stipulating that good water should be odorless. The absence of odor in water indicates that the water is free from contamination of organic or inorganic compounds that may affect its sensory quality. Water odor often indicates the presence of pollutants such as industrial waste or hazardous chemicals that can contaminate water quality. Undetectable odor in water indicates good physical quality, where the water does not contain compounds or materials that can affect human health. Research by Yalaletdinova et al. (2021) also states that water without odor is a sign of good quality, and this indicator can be used as an initial parameter to assess the feasibility of water before further tests are carried out. Thus, the results of this odor test indicate that the tested water is safe for use.

The color of the tested water showed a value of less than 1.2 TCU, much lower than the quality limit suggested by a maximum of 10 TCU. The clarity of this water is excellent, indicating no contaminants that cause discoloration, such as heavy metals, organic matter, or harmful chemicals. Clear water tends to be more visually appealing and safer for users. This very low color indicates that the water is free of substances that could interfere with further treatment. This reduces the cost and effort in water treatment, as clear water is easier to filter and clean. Research by Yalaletdinova et al. (2021) confirms that low-color water is directly related to the health and resilience of aquatic ecosystems. For example, color pollutants may indicate more widespread pollution in the source area.

The water's Total Dissolved Solids (TDS) was 247 mg/L, which is still within the quality standard limit of < 300 mg/L. A low TDS indicates that the water is not contaminated with harmful dissolved substances, such as salts or industrial chemicals, which can affect the taste and quality of the water. These dissolved solids often come from water exposed to chemical pollution or industrial activities. However, even if the TDS of this water is within safe limits, it should be noted that a mineral content that is too low can also affect the taste of the water, which may be less desirable to consumers. Therefore, although the TDS of the tested water meets the standard, further research into the types of solutes present in this water is highly recommended. Ridarto et al. (2023) mentioned that a balanced TDS is significant in maintaining the taste and quality of water, especially for human consumption.

The measured turbidity value was 0.71 NTU, much lower than the recommended quality limit of <3 NTU. Low turbidity indicates that the water does not contain solid particles that can impair water quality, such as dirt, sand, or other microscopic substances. Water with low turbidity is generally safer because it reduces the chance of infection due to germs or microorganisms trapped in turbidity particles. In addition, low turbidity also facilitates the water treatment process, as water with fewer particles is easier to filter and process further. Research by Fahimah et al. (2023) shows that water with low turbidity is safer and more efficient in processing. Therefore, these results confirm that the tested water quality is excellent regarding turbidity.

The temperature of the tested water was 28.3°C, which is within the air temperature quality standard of ± 3°C. This temperature indicates that the water is stable to support aquatic life. Temperatures that are too high or too low can affect the survival of organisms in water and the chemical and biological processes that occur in it. An optimal temperature is critical in maintaining the balance of the aquatic ecosystem. This maintained temperature also indicates no influence of thermal pollution from industrial activities or hot water discharges that can damage water quality. Akpan et al. (2025) emphasized that stable temperature is a key factor in maintaining water quality, both in terms of organism health and in maintaining water's physical and chemical properties.

The analysis showed a water pH of 7.37, within the quality standard range of 6.5 to 8.5. A stable pH supports the various biochemical processes that occur in water and maintains the health of aquatic ecosystems. Good pH quality also indicates that the water is not contaminated by chemicals that can change the pH to more acidic or alkaline. In addition, a neutral pH also makes this water safer for human consumption, because water with extreme pH (too acidic or alkaline) can irritate the skin and digestive tract Dewangan et al., (2023) revealed that maintaining pH is very important in maintaining water quality and keeping it safe for various human and environmental needs.

The nitrate as nitrogen (NO3-N) content in the water was 0.119 mg/L, much lower than the quality standard limit of 20 mg/L. Nitrate dissolved in water can come from agricultural waste or chemical disposal pollution. This low nitrate indicates that the tested water is free from nitrate pollution that can harm health, causing methemoglobinemia or respiratory problems. The results show nitrate levels, so this water is safe for human consumption and other purposes. Research by Picetti et al. (2022) states that water with low nitrate levels is perfect for health, especially to prevent health problems caused by the consumption of nitrate-contaminated water.

The nitrite nitrogen value detected was <0.002 mg/L, which is very low and well below the quality standard limit of 3 mg/L. Nitrite is a compound formed from the reduction process of nitrate and is very dangerous if accumulated in the body, as it can cause impaired blood oxygenation, especially in infants. This low nitrite content indicates that the water is free from contamination that can cause health problems. Water with a low nitrite content indicates that the water treatment and filtration process has worked well, and harmful compounds do not contaminate the water. Chaudhary et al. (2025) noted that low nitrite levels indicate water quality that is safe and suitable for use.

The hexavalent chromium content in the tested water was <0.001 mg/L, much lower than the maximum limit of 0.01 mg/L. Hexavalent chromium is a hazardous heavy metal, as it can cause cancer, kidney disorders, and various other diseases. Water with low chromium content indicates no heavy metal contamination, which means it is safe for daily activities, including human consumption. In addition, these results show that water source management has been done well to avoid heavy metal contamination. Reprint & Muhammad (2024) stated that low levels of hexavalent chromium in water are essential to protect public health from potential heavy metal poisoning.

No E. Coli and total coliform bacteria were found in the tested water, with 0 CFU/100 mL values for both parameters. E. Coli and total coliforms are key indicators of fecal contamination that can cause various infectious diseases, such as diarrhea and gastrointestinal infections. The absence of these bacteria indicates that the water is safe and free from microbiological contamination that can harm health. Water free from microbiological contamination is essential for the sustainability of human health. Tropea (2022) reveals that good microbiological quality is a key indicator of water that is fit for consumption and safe for various purposes. With this result, the tested water can be ensured to meet the physical and chemical standards and the health requirements.

Water quality testing is a continuous process that should be conducted regularly to ensure public health and environmental safety. The results for each parameter must be compared against national and international water quality standards established by the World Health Organization (WHO) and local regulatory agencies. Regular testing also helps monitor seasonal changes in water quality and identify potential sources of contamination. This enables timely intervention and preventive measures to safeguard the community's water supply.

4. CONCLUSION

The water quality tested in the effluent generated from the organic fertilizer production process meets the quality standards set by Government Regulation No. 22 of 2021 regarding liquid waste management and environmental protection. The analysis results of physical, chemical, metal, and microbiological parameters show that the water is not contaminated by hazardous materials, such as odor, color, heavy metals, or pathogenic microorganisms, which can endanger human health or the environment.the The tested water quality is within safe limits and meets applicable regulations. Therefore, effluent management efforts can effectively minimize negative impacts on local water quality. This research makes a novel contribution to the industrial water quality management literature by highlighting the application of environmental regulations in the context of a sustainable agricultural industry, particularly in the organic fertilizer production sector. The case of PT Bio Maraja Nusantara highlights how regulatory compliance, supported by integrated technological solutions, can effectively mitigate environmental risks while promoting sustainable production. the success of this study demonstrates the importance of proper effluent monitoring and treatment to ensure the sustainability of water compliances resources and ecosystem protection.

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