

# Analysis of Brewery Waste and Impact on the Environment in Hera, Timor-Leste

Elisabet Andrijani Tarwanti, Antero Freitas Branco 

Department of Biology Teaching, Faculty of Education Arts and Humanity, University National of Timor-Leste, Dili, Timor-Leste  
Email: elisabeth.tarwanti@untl.edu.tl, antero.branco@untl.edu.tl

**How to cite this paper:** Tarwanti, E. A., & Branco, A. F. (2025). Analysis of Brewery Waste and Impact on the Environment in Hera, Timor-Leste. *Journal of Geoscience and Environment Protection*, 13, 314-326. <https://doi.org/10.4236/gep.2025.137019>

**Received:** May 28, 2025

**Accepted:** July 25, 2025

**Published:** July 28, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0). <http://creativecommons.org/licenses/by/4.0/>



Open Access

## Abstract

The beer beverage industry is currently growing very rapidly, and because of these activities, the beverage industry can produce waste on a large or small scale. The results of small-scale waste can decompose naturally, but large-scale waste can be harmful to the environment. Therefore, large-scale factory waste can produce very dangerous waste for the environment and its components. The brewery is the only brewery in the country of Timor-Leste. With the idea that the brewery in Hera, Timor-Leste, has processed its waste properly and is safe for the environment, it is necessary to prove that the liquid waste of the beer beverage factory does not hurt the environment. This study aims to analyze the quality of the beer factory's liquid waste and the quality of the water where the beer beverage liquid waste is disposed of. The method used in this study is the intentional sampling method or also known as judgment sampling. Sample analysis was conducted at the Forestry and Environment Laboratory of Bali Province, Indonesia, from December 14, 2023, to December 23, 2023. From the results of the laboratory tests, it can be concluded that the liquid waste from the Hera brewery, Timor-Leste, has a normal pH, high turbidity, low DO levels, and high BOD levels. This harms the marine environment where the liquid waste is disposed of, because it can cause the death of marine organisms, disrupt the balance of the marine ecosystem, and cause irreversible damage. Therefore, the Timor-Leste Government must conduct regular waste inspections and establish regulations on the maximum concentration of pollutants contained in brewery waste that can be discharged into the environment, as explained in the regulations of the Minister of Environment and Forestry of the Republic of Indonesia. In short, breweries must review their liquid waste treatment process before discharging it into the environment so that the waste produced does not comply with the laws and regulations that must be established. And it is suggested to the Government and the Timor-Leste Environmental Nacional Agency or ANLA to always conduct periodic field inspections to check the quality of beer liquid waste on the environmental impact so as not

---

to damage the water and soil environment and all living things.

## Keywords

Analysis, Brewery, Waste, Impact, Environment

---

## 1. Introduction

In everyday life, humans with their activities must produce waste, both solid and liquid and in a certain amount and volume. So that even though the waste on a small scale can be described naturally without causing significant problems, accumulation on a large scale can interfere with environmental balance. Waste resulting from business activities or activities that contain dangerous, toxic materials and various components, causing threats to the environment, human health, and the survival of other living things.

Common materials in waste include organic compounds that can be degraded, volatile, difficult to compose, toxic heavy metals, suspended solids, nutrients, pathogenic microbes, and parasites. Liquid waste content, in the form of discharged fluids into the environment, can cause problems for the environment. Wastewater, which comes from domestic and industrial activities, is in dire need of adequate maintenance before being discharged to the environment to ensure water quality standards. Considering the composition and nature of waste and the content of compounds is very important to handle it properly to avoid being a dangerous pollutant.

By the provisions relating to liquid waste treatment, including fouling prevention in surface waters, as well as biota protection functions in the soil and waters, prevention of disease and vectors such as mosquitoes, cockroaches, and flies, and preventing unpleasant and unpleasant environmental conditions. Types of waste are grouped based on their shape to be liquid, solid, gas, and sound. In the context of liquid waste, it can be classified into four different groups: 1) Domestic liquid waste: from houses, such as soapy water, detergent water, and feces water. 2) Industrial liquid waste, including water waste from the food and beverage processing industry. 3) Infiltration or Overflow: liquid waste from various sources that enter the waste drain with infiltration into the soil through surface overflow. 4) Stormwater: liquid waste that can carry solid or liquid waste particles. This plot highlights the diversity and origin of liquid waste, so it is important to apply effective environmental processing and management practices.

The place of beer production, which was recognized because of its international presence, arrived in Asia in 1929, but only in 2017 established this beer drink company in Timor-Leste. The main purpose of establishing the first international manufacturing unit in the country is to capitalize on the market opportunities. This project marks a significant investment of millions of dollars and estimates the production of several international beer brands, such as Bintang, Tiger, and ABC, as well as several non-alcoholic beverage brands.

The start of the inauguration of the beer factory is one of the important milestones for the small country of Timor-Leste, to increase the value of foreign investment and create employment opportunities. However, despite all the threats of environmental pollution and irresponsible waste management patterns produced by the industry, especially in the context of beer production and the production of liquid waste, it is very important to reduce the negative impact on the environment and water quality.

At this time in Timor-Leste, efforts to manage liquid and dense waste face significant challenges because there is currently no special installation to process all waste, which results in the disposal of waste on land, water, and even in the sea, which is a threat to the environment and aquatic biota. The main problem faced is the lack of adequate infrastructure to deal with waste, which in terms of number and volume is getting more and more that, causing dangerous consequences. Pollution, understood as any harmful change in the environment, can occur in natural, agricultural ecosystems, or living systems on a micro scale (Yadav et al., 2024). In general, there are several types of environmental pollution, such as air, soil, and water pollution. Water pollution, specifically, refers to the introduction of foreign particles that can be harmful to the fauna, flora, and human populations neighboring or that depend on this water (Carapeto, 1999).

When addressing water pollution, it is essential to consider water quality. Water quality is defined by the variation of intrinsic parameters, being variable in time and space (Wu et al., 2024). Minimizing water pollution requires the precise maintenance of water quality, enabling its adequate management and, if necessary, its remediation, caused by human interference in aquatic systems (EPA, 2012).

In the context of the brewery in Timor-Leste, beer production generates waste, such as brewery starch residue, a by-product with a high protein content, rich in fiber, neutral detergent (NDF), total carbohydrates (TC), and ether extract (EE). The Timorese government signed an investment agreement with Beer Company in Asia Pacific for the construction of a factory in Dili, including the production of beer, soft drinks, and water. The project, opened in 2017, represents a significant investment and has the potential to generate direct and indirect jobs in the country.

Liquid waste is wastewater produced from human activity, which contains harmful pollutants in the short and long term. Different from households and industrialists, this residue carries organic and inorganic pollutants, mostly found in deferred particles. The presence of this pollutant is a serious threat to environmental sustainability and becomes a poison to all types of aquatic biota, and affects the physical, chemical, and biological properties of the water body. In short, changes like water due to pollutants can result in degradation of water quality both directly and indirectly, negatively impacting the sustainability of freshwater ecosystems and seawater. Waste is a substance produced from the production process, both industrial and domestic, classified into four types based on its characteristics: liquid waste, solid waste, gas waste, and particle residue.

## 2. Fundamental Theory

At this time in Timor-Leste, efforts to manage liquid and dense waste face significant challenges because there is currently no special installation to process all waste, which results in disposal of waste on land, water and even to the sea which is a threat to the environment and aquatic biota. The main problem faced is the lack of adequate infrastructure to deal with waste which in terms of number and volume is getting more and more that cause dangerous consequences.

Pollution, understood as any harmful change in the environment, can occur in natural, agricultural ecosystems or in living systems on a micro scale (Yadav et al., 2024). In general, there are several types of environmental pollution, such as air, soil and water pollution. Water pollution, specifically, refers to the introduction of foreign particles that can be harmful to the fauna, flora and human populations neighboring or that depend on this water (Carapeto, 1999). When addressing water pollution, it is essential to consider water quality. Water quality is defined by the variation of intrinsic parameters, being variable in time and space (Wu et al., 2024). Minimizing water pollution requires the precise maintenance of water quality, enabling its adequate management and, if necessary, its remediation, caused by human interference in aquatic systems (EPA, 2012).

In the context of the brewery in Timor-Leste, beer production generates waste, such as brewery starch residue, a by-product with a high protein content, rich in fiber, neutral detergent (NDF), total carbohydrates (TC) and ether extract (EE). The Timorese government signed an investment agreement with Beer Company in Asia Pacific for the construction of a factory in Dili, including the production of beer, soft drinks and water. The project, opened in 2017, represents a significant investment and has the potential to generate direct and indirect jobs in the country.

Liquid waste is wastewater produced from human activity, which contains harmful pollutants in the short and long term. Different between households and industrialists, this residue carries organic and inorganic pollutants, mostly found in deferred particles. The presence of this pollutant is a serious threat to environmental sustainability and becomes a poison to all types of aquatic biota and affects the physical, chemical and biological properties of the water body. In short, changes in the nature of water due to pollutants can result in degradation of water quality both directly and indirectly, negatively impacting the sustainability of freshwater ecosystems and sea water. Waste is a substance produced from the production process, both industry and domestic, classified into four types based on its characteristics: liquid waste, solid waste, gas waste, particle residue.

## 3. Methods of Research

The method used in this research is intentional sampling, also known as judgmental sampling. This method is part of the group of non-probability sampling, standing out for the active participation of the researchers in the selection of population elements that will be included in the sample (Makwana et al., 2023). The sample

studied consists of effluents from the sewage of the brewery located in Timor-Leste, which were processed at the factory and discarded into the environment. The research location is the Brewery located in Timor-Leste. Laboratory tests were carried out at the Laboratory of the Ministry of Forestry and Environment, Bali Province, Indonesia.

### 3.1. Time of Research

This research was done on the first of December 14 2023 to December 23, 2023 in Hera Village, Metinaro Sub District, Timor-Leste.

### 3.2. Equipments and Materials

The equipment: a) Effluent from the brewery in Hera, Timor-Leste. b) Tape measure. c) Measuring Cup. d) Plastic Bottles and Paper. e) Photo camera.

### 3.3. Survey Sample

The samples in this research consist of effluents from the brewery factory in Hera, Timor-Leste, which have at sea.

### 3.4. Sampling and Chemical Analysis of Effluents

a) Observation: Carried out to identify the disposal site for the brewery's liquid waste and determine how to collect samples.

b) Sampling: Sampling was carried out at 3 points: 1) First point, 0 meters, at the waste disposal site (sewer). 2) Second point, 150 meters from the effluent outlet. 3) Third point, 300 meters from the effluent outlet.

c) Effluent Analysis: For the analysis of effluent characteristics, pH and turbidity measurements were carried out: pH analysis was carried out using the (protocol) based on the Indonesian National Standard (SNI 06-6989.11-2004) (Harris, 2004a). In this method, the pH of water (wastewater) is analyzed using a specific meter with the purpose of determining the acidity level in the solution (sample).

### 3.5. Data Analysis Strategy

Dissolved Oxygen Analysis (DO) and Biochemical Demand of Oxygen (BOD). DO Analysis: Performed in accordance with the norms of the Indonesian National Standard SNI 06-6989.14-2004 (Harris, 2004b). The value of DO was calculated using the formula (Piveli & Kato, 2006).

$$\text{dissolved oxygen} \left( \frac{\text{mg}}{\text{l}} \right) = \frac{V \times N \times 8000}{V_{\text{amostra}}}$$

With understanding: V, is the volume of  $\text{N}_2\text{S}_2\text{O}_3$  ml N, the normality of  $\text{N}_2\text{S}_2\text{O}_3$ . The formula for calculating the BOD is:

$$\text{BOD} \left( \frac{\text{mg}}{\text{l}} \right) = \frac{(A_1 - A_2) - \left[ \frac{(B_1 - B_2)}{V_B} \right] V_C}{P}$$

where:

$A_1$  is the dissolved oxygen concentration of the sample before incubation (0 day) (mg/l).  $A_2$  is the dissolved oxygen concentration of the sample under study after 5 days and 6 hours of incubation (mg/l).  $B_1$  is the dissolved oxygen concentration of analytical white before incubation (0 days) (mg/l).  $B_2$  is the dissolved oxygen concentration of analytical white after 5 days and 6 hours of incubation (mg/l).  $V_B$  is the volume of microbial suspension (ml) in a blank DO bottle.  $V_s$  is the volume of microbial suspension in a test sample vial (ml).  $V_w$  is the volume of wastewater whose BOD will be measured. For sample measurements, use 50 - 300 ml sample.  $P$  is the comparison of test sample volumes ( $V_1$ ) by total volume ( $V_2$ ).  $P$  is the volume used, usually the amount of sample used is 50 - 300 ml.

$$BOD\left(\frac{mg}{l}\right) = \frac{(C_1 - C_2) - \left[\frac{(B_1 - B_2)}{V_B}\right] V_s}{P}$$

where:

$C_1$  is the oxygen level dissolved in the bottle containing the 0 (zero) day glutamic glucose-acid solution (mg/l).  $C_2$  is the dissolved oxygen level in the bottle containing the glucose solution after 5 days and 6 hours incubation (mg/l).  $B_1$  is the oxygen level dissolved in analytical white at 0 days (mg/l).  $B_2$  is the level of oxygen dissolved in analytical white at 5 days and 6 hours (mg/l).  $V_B$  is the volume of microbial suspension (mL) in DO bottle in analytical white.  $V_s$  is the volume of microbial suspension by DO bottle (mL) in the container containing the glucose-glutamic glucose control solution.  $P$  is the ratio between the volume of the test sample and the diluent solution.

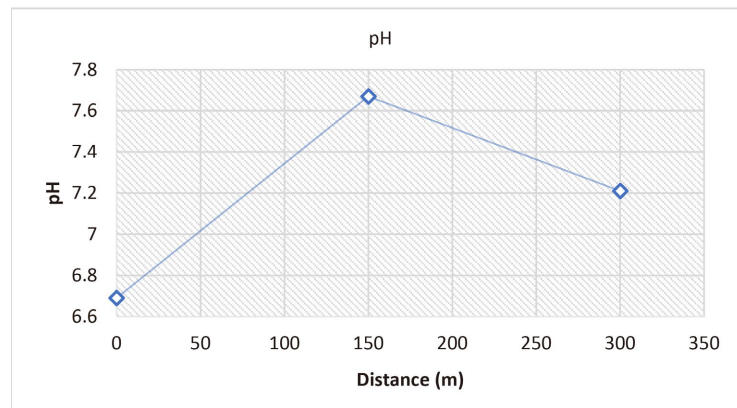
#### 4. Results and Discussion

By the sampling procedure carried out to identify points where it becomes the purpose of disposal of waste, where beer waste is being discarded, because this greatly affects the surrounding environmental conditions, where the samples analyzed in this study must be collected in a clean container. Sampling was carried out at three different points because of the climatic conditions at that time in Timor-Leste, which was in a hot and drought-dominated climate.

Because the channel where beer waste residues are discarded is in a dry state, and the flow of water is only available at a distance of about 300 meters. The main purpose of storing these samples is to preserve the number of microorganisms contained therein, keep them during sampling. This is done to avoid a reduction or duplication of the number of microorganisms until the sample is ready to be analyzed in the laboratory.

The results of the pH test in the laboratory indicate that the lowest pH is 6.69 at the effluent discharge site, and the highest pH is 7.67, 150 meters from the discharge site (Figure 1). Based on the regulation of the Minister of Environment and Forestry of the Republic of Indonesia in 2021, the wastewater quality standard for brewing companies or industries is 6.0 to 9.0. Therefore, the values obtained

by this study fall within what is legally acceptable for the effluent in question. Water with a pH lower than 6 will be very acidic and harmful to the environment, and if the water has a pH above 9, it will have a high alkaline content, harming the environment (Makwana et al., 2023). From the results obtained, it is possible to verify that the pH of the sea water around the brewery in Hera is within the normal limit based on the SNI for the pH of effluents from the brewing industry.



**Figure 1.** Graph test results pH at different sampling points.

According to the graph, Looking at the instability of the pH value even though it is still in the normal category, the initial point of measurement of pH 6.67 is below the normal value, after a medium distance of 150 meters the pH is 7.65 due to an increase in pollutant elements in the water that have accumulated a lot, the furthest distance of 300 meters the pH drops to 7.2, this shows that there is a slight decrease in the pH value along with the distance, therefore the further away from the pollutant point the pH quality of the water improves somewhat.

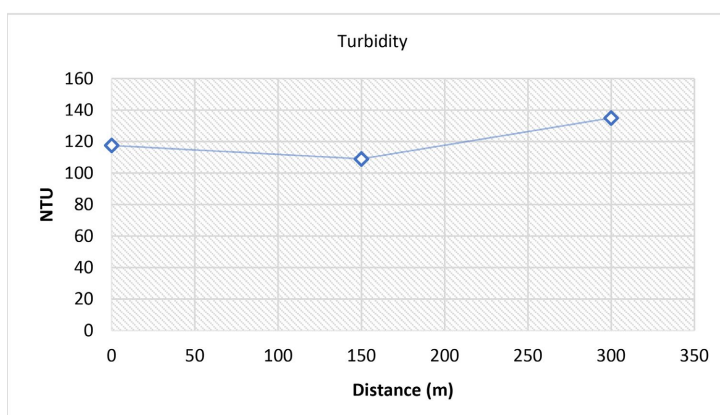
#### 4.1. Turbidity Test

The results of the laboratory turbidity test show that this is less than 150 meters from the discharge site (109 NTU), and the highest was recorded at 300 meters from the discharge site (135 NTU) (Figure 2). The turbidity of seawater is the amount of suspended substances/organisms in seawater that can block sunlight. The higher the turbidity of seawater, the lower its transparency (Haule et al., 2024). Turbidity can be caused by various types of suspension material; the more material is suspended, the cloudier the water (Haule et al., 2024).

Based on the decision of the Minister of Forests and the Environment (no.16/Menl.HK/Setjen/Kum.1/4/2019), the normal limit of seawater turbidity values is fixed between 5 and 25 NTU (Nephelometric Turbidity Unit). The results obtained in this test are far superior to those recommended, which can lead to the disturbance of marine ecosystems. The suspension particle may affect the amount of light entering the water, affecting the process of photosynthesis and growth of marine organisms, mainly from different species of phytoplankton, zooplankton, and macroalgae.

On the graph, the high turbidity level, the turbidity level value at the starting point has 119 NTU, at a distance of 150 meters there is a slight decrease of 110 NTU, due to the influence of water flow and not being stagnant tends to flow, at a distance of 300 meters there is an increase in value of 138 NTU, this occurs due to the accumulation of turbidity due to stagnant wastewater in one place.

Based on the results of laboratory tests, it can be concluded that turbidity levels at the brewery's liquid waste elimination are very based on the Indonesian National Standard (SNI), which has an impact. Its impacts are: blocking sunlight in the water, reducing the photosynthesis process in aquatic plants and phytoplankton. This causes oxygen production to decrease and interrupts the aquatic food chain, altering the population of organisms that suspended particles can be based on and cover the bottom of the water, causing turbidity and water absorbs more heat from sunlight, causing water temperature to increase, causing poor water quality. In general, high levels of turbidity can disturb the balance of the aquatic ecosystem and cause various environmental and health problems.



**Figure 2.** Graph results of the turbidity test of the gathered effluents in the different sampling sites.

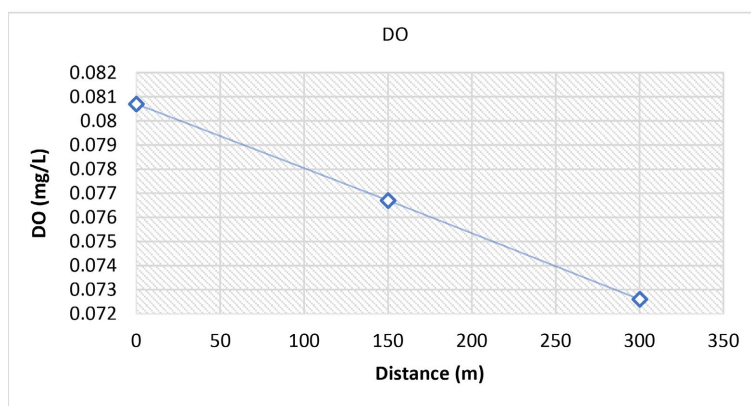
#### 4.2. DO Test (Dissolved Oxygen)

The DO level in seawater around the brewery is higher at the effluent outlet (0 meters from the sewage outlet), which is 0.0807 mg/l, and the lowest level of DO is found 300 meters from the sewage outlet, being 0.0726 mg/l (**Figure 3**). DO levels affect water quality. If DO levels are low, therefore indicates a problem of pollution or environmental degradation. Dissolved oxygen is a basic necessity for the lives of living beings in water (*Afzal et al., 2023*).

Marine life, like fish and plankton, needs dissolved oxygen. For they are aerobic organisms. If DO levels are low, it can interfere with your survival. When the DO level is less than 5 mg/l, then the waters are categorized as containing low oxygen content, and if the low value can cause anoxia situations, which is a condition in which the lack of oxygen in water causes mass death and marine life (*Borges et al., 2023*).

DO is one of the important parameters in water quality analysis. The DO value

indicates the amount of oxygen ( $O_2$ ) available in a water body, and the water quality will be better the closer to saturation the DO values approach. On the other hand, a low DO value may indicate weak oxidizing power. Dissolved oxygen has a significant effect on water quality: the higher the value of the DO, the greater the ability of the water to oxidize and degrade pollutants. The standard value of DO quality is an important reference to evaluate water quality and ensure adequate conditions for aquatic life. DO plays an essential role in the survival of aquatic life, and ideally must approach 8 mg/l to ensure the survival of all aerobic marine species.



**Figure 3.** Graph concentration of DO (mg/L) in effluents collected in the different sampling sites. Sources of Data.

On the DO value graph, the low DO value at the starting point where there is a high concentration due to the accumulation of pollutant waste at the starting point of 0.079 mg/L, at this point there is an accumulation of pollutant elements that gather and experience high concentrations. At a distance of 150 meters, it has a value of 0.0765 mg/L. At this point, there is a slight decrease in value because the water flow moves at this distance, there is a decrease in DO concentration. At a distance of 300 meters, which is the furthest distance, it has a value of 0.0725 mg/L, there is a decrease in DO levels because it is far from the point of pollution.

To reduce oxygen levels (DO) in the liquid waste of the brewery several methods can be used, including the anaerobic deposition method, which consists of removing organic matter in waste, can also be done using the bi-restraint system using anaerobic microorganisms to classify organic matter in residue can also use activated sludge, microorganisms in the activated sludge will consume dissolved oxygen and increase the level of DO in the waste. Thus, the Government of Timor-Leste and the brewery should monitor the DO level, regularly inspect the brewer's effluent owners, and in places near the discharge site.

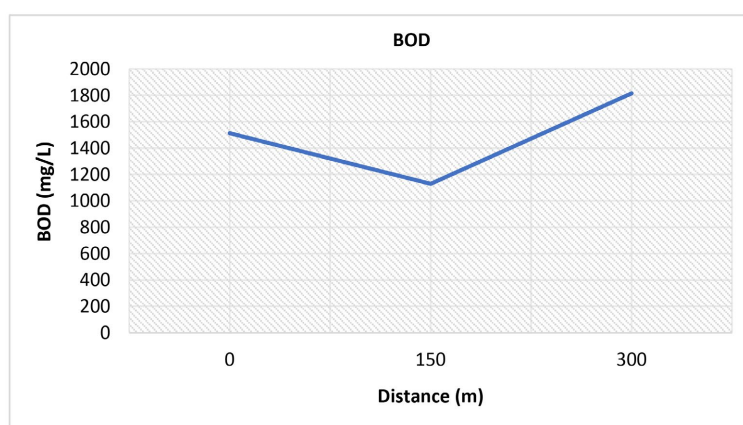
### 4.3. Biochemical Oxygen Demand Test (BOD)

BOD levels in the sea vary depending on the level of water pollution. The BOD test shows that measuring the amount of dissolved oxygen required by microor-

ganisms to completely decompose organic matter in water. High BOD values indicate the presence of more organic matter that requires decomposition. The BOD value states the amount of oxygen, but for simplification, it can be interpreted as a general description of the amount of biodegradable organic components present in the waters (Mocumba, 2010).

BOD level measurements are currently used for the following considerations: it is important to estimate the approximate amount of oxygen required to decompose existing organic matter, determine the size of the wastewater treatment unit installation, evaluate the efficiency of a wastewater treatment process, and verify its compliance with the permitted limits for wastewater discharge. Based on SNI, the permitted boron level for a brewery (the highest) is 40 mg/L.

In this work, the lowest level of BOD was found at a distance of 150 meters from the effluent output (1129.03 mg/l), and the highest BOD level is at a distance of 300 meters (1814 mg/l) output (Figure 4). This result denotes that BOD in seawater around the brewery exceeds 40 mg/l, recommended by the SNI 06-6989.25-2005, and will be harmful to the environment. As the value of BOD is high, according to environmental quality standards, there is evidence of organic matter pollution (Haris, 2005).



**Figure 4.** Graph concentration of BOD (mg/L) in effluents collected in the different sampling sites.

In this BOD graph, the high BOD value in beer waste that is unstable at each distance shows that there are indications that the beer waste is not processed perfectly and the disposal mechanism does not pay attention to environmental safety. At the starting point of 1500 mg/L, it has a high concentration due to the accumulation of pollutant elements that gather because they are stagnant in one place. At a distance of 150 meters, at this point, there is a decrease in BOD levels of 1100 mg/L due to the influence of moving and non-stagnant water flow. At a distance of 300 meters, it has a value of 1800 mg/L. At this point, this occurs due to the accumulation of BOD that is concentrated in one place, so it has a fairly high value.

Based on the results obtained, the BOD test has very high values that may be a consequence of organic pollutants from agricultural flow or industrial waste entering the aquatic environment. This increased BOD negatively impacts aquatic ecosystems and water quality causing a decrease in dissolved oxygen levels, changes in ecosystem structure, biodiversity loss, and changes in nutrient cycles, reducing habitat quality to different ecosystem species.

## 5. Conclusion

According to the results obtained from the analysis of liquid waste that has been discharged into the environment by the ivy brewery, Dili Timor-Leste it can be concluded that: 1. Waste from the brewery, located in Hera, Dili, Timor-Leste, which is discharged into the open sea, can be considered relatively dangerous because of the high levels of BOD, turbidity and reduced DO values found at the sampling location. 2. The results of the investigation presented indicate the weak quality of seawater around the brewery environment, each of the physicochemical parameters mentioned has a negative impact on the environment as follows: High BOD levels can result in the death of marine organisms, disruption of the ecosystem balance, unpleasant odors due to the decomposition process of organic matter and contribute to algal blooms that can produce explosions that can produce toxic elements that are harmful to aquatic life and humans; High turbidity levels and exceeding predetermined limits can cause aesthetic disturbances, reduce the effectiveness of water disinfection by preventing the elimination of pathogenic organisms and even stimulating their proliferation, increase the concentration of nitrogen compounds and contribute to the production of unpleasant odors; Very low DO concentration in water indicates that the water is of poor quality and if the condition is considered hypoxic, there is a high possibility of causing mass death of aquatic organisms. Instability of the pH value even though it is still in the normal category, the high turbidity level, the low DO value at the starting point where there is a high concentration due to the accumulation of pollutant waste, and the high BOD value in beer waste that is unstable at each distance shows that there are indications that the beer waste is not processed perfectly and the disposal mechanism does not pay attention to environmental safety. The Timor-Leste Government must conduct regular waste inspections and establish regulations on the maximum concentration of pollutants contained in brewery waste that can be discharged into the environment.

## 6. Solution

The results of the study on the Analysis of beer waste pollution against environmental pollution due to not being recycled perfectly. Looking at the instability of the pH value even though it is still in the normal category, the high turbidity level, the low DO value at the starting point where there is a high concentration due to the accumulation of pollutant waste, and the high BOD value in beer waste that is unstable at each distance shows that there are indications that the beer waste is

not processed perfectly and the disposal mechanism does not pay attention to environmental safety. This can be seen from the disposal of waste that pollutes the soil, water body and marine environment in the near and around the beer industry. So that it is better before being discharged into the environment, there must be more serious attention for beer beverage companies to be more careful in the system of recycling liquid waste safely before being discharged into the environment so as not to damage the environment. So that the beer liquid waste does not threaten the existence of all organisms in the beer liquid waste disposal path. And it is suggested to the Government and the Timor-Leste Environmental Nacional Agency or ANLA to always conduct periodic field inspections to check the quality of beer liquid waste on the environmental impact so as not to damage the water and soil environment and all living things.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

### References

- Afzal, M. S., Tahir, F., & Al-Ghamdi, S. G. (2023). Impact of Onshore Construction Activities on Sea Water Turbidity. In: *Environmental Science and Engineering* (pp. 17-24.), Springer Nature Singapore. [https://doi.org/10.1007/978-981-99-4101-8\\_2](https://doi.org/10.1007/978-981-99-4101-8_2)
- Borges, F. O., Sampaio, E., Santos, C. P., & Rosa, R. (2023). Impacts of Low Oxygen on Marine Life: Neglected, but a Crucial Priority for Research. *The Biological Bulletin*, 243, 104-119. <https://doi.org/10.1086/721468>
- Carapeto, C. (1999). *Poluição das águas: Causas e efeitos*. Universidade Aberta.
- EPA (2012). *Water Quality Standards Handbook*. <https://www.epa.gov/sites/default/files/2014-10/documents/handbook-chapter2.pdf>
- Haris, Z. (2004a). *SNI 06-6989.11-2004: Air dan air limbah-Bagian 11: Cara uji kesadahan total dengan metode titrimetric*. Badan Standardisasi Nasional.
- Haris, Z. (2004b). *SNI 06-6989.14-2004: Air dan air limbah-Bagian 14: Cara uji zat padat tersuspensi total (TSS)*. Badan Standardisasi Nasional.
- Haris, Z. (2005). *SNI 06-6989.25-2005: Air dan air limbah-Bagian 25: Cara uji kadar minyak dan lemak secara gravimetri*. Badan Standardisasi Nasional.
- Haule, K., Kubacka, M., Toczek, H., Lednicka, B., Pranszke, B., & Freda, W. (2024). Correlation between Turbidity and Inherent Optical Properties as an Initial Recognition for Backscattering Coefficient Estimation. *Water*, 16, Article 594. <https://doi.org/10.3390/w16040594>
- Makwana, D., Priti, E., Amisha, D., & Hardik, C. (2023). Sampling Methods in Research: A Review. *International Journal of Trend in Scientific Research and Development*, 7, 1-7.
- Mocumba (2010). *Dissolved Oxygen and Biochemical Oxygen Demand in the Waters Close to the Quelimane Sewage Discharge*. Eduardo Mondlane University. <https://doi.org/10.13140/2.1.1504.9288>
- Piveli, R. P., & Kato, M. T. (2006). *Qualidade das águas e poluição: Aspectos físico-químicos, USP, EFSP, Brasil*. <https://www.mrclab.com/all-information-questions-and-answers-about-biochemical-oxygen-demand>

Wu, H. W., Wu, F., Li, Z. H., Gao, X., Wu, X., & Bao, G. (2024). Considering Scale Effects in Water Quality Analysis to Enhance the Precision of Influencing Factor Response Analysis. *Ecological Indicators*, 163, Article 112091.

<https://doi.org/10.1016/j.ecolind.2024.112091>

Yadav, P. K., Sachan, R., & Dwivedi, D. K. (2024). Ecological Consequences: Understanding the Effects of Agricultural Pollution on Ecosystem, Wildlife, and Biodiversity. *Researchgate*. <https://www.researchgate.net/publication/377874352>