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Evaluation of Water Quality Degradation Associated with an Ethanol/Wastewater Spill in Bais City, Negros Oriental Using Quantitative Water Quality Variables

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ABSTRACT

The quantitative research method assessed changes in water quality before and after the ethanol and wastewater spill in Negros Oriental using secondary data from the government and publicly available reports. The major discharge from the Universal Robina Corporation’s ethanol distillery facility occurred on October 24, 2025, followed by the collapse of a containment dike on the evening of October 26, 2025. This incident released an estimated 255,000 cubic meters (67 million gallons) of wastewater into North Bais Bay and the Tañon Strait Protected Seascape, a critical marine habitat. The environmental disaster significantly affected the livelihoods of communities in Bais City and the adjacent municipality of Manjuyod, both of which declared a state of calamity due to extensive fish kills. Government agencies, including the Similar spill incidents had been recorded in previous years, including one in 2015, indicating a recurring issue. Comparable approaches have been applied in both local and international studies to evaluate the effects of industrial wastewater discharges on water quality. In the United States, the effects of the Gold King Mine wastewater spill on water quality were assessed using secondary data in monitoring the changes in water quality (U.S. Environmental Protection Agency, 2019). Likewise, in Vancouver, Canada, monitoring data supported assessments of untreated wastewater releases into coastal waters. The results of this study revealed detectable post-spill changes in selected water quality parameters, indicating a decline in water quality. Overall, the findings demonstrate that secondary data analysis is an effective method for assessing the environmental impacts of wastewater spill incidents.

Keywords: Water Quality Assessment; Ethanol; Wastewater Spill; Coastal Pollution; Negros Oriental

INTRODUCTION

Water quality is an important factor in determining the health of aquatic ecosystems and has significant applications in the support of biodiversity, human use, and livelihoods. Unfortunately, water sources continue to be under threat because of industrial processes, especially the disposal of wastewater that is either untreated or insufficiently treated. The disposal of wastewater into water sources may lead to the introduction of organic materials, nutrients, and chemicals, which may contribute to the modification of the physical and chemical properties of water, resulting in reduced levels of dissolved oxygen, biological oxygen demand, turbidity, and pH. Such alterations can disrupt aquatic life, impair ecosystem functions, and pose risks to communities that depend on these water resources for food and economic activities.

Analysis of the quality of the water before and after the pollution incident can be an effective method for determining the level of environmental effect created by the discharge of wastewater. Through quantitative analysis, the quality of the parameters in the water can be measured to determine whether the quality of the water has been affected by the pollution incident.

The spill of ethanol and wastewater in Negros Oriental created concern about the potential impact of the spill on nearby coastal waters and aquatic ecosystems. It is important to understand the impact of the spill on water quality to ensure environmental conservation and management. This study aimed to investigate water quality before and after the spill using secondary environmental data and quantitative research methodology. Through an assessment of critical water quality indicators including dissolved oxygen, biological oxygen demand, turbidity, and pH, the study sought to provide scientific proof of water quality impact caused by the spill.

LITERATURE REVIEW

Water quality is a concern because of the direct impact it has on the health of the area and the livelihood of the people. Water is affected by natural and man-made components such as industrial processes and wastewater (Chapman, 1996; Tyagi et al., 2013). Changes in the key parameters of water are regarded as significant and are used to assess the impact of the stress and spills of wastewater (Kannel et al., 2007). Specifically in the case of the Philippines, the concern on the spills of industrial wastewater is serious since it tends to affect the coastal communities which depend on the aquatic habitat for their livelihood (DENR-EMB, 2025). There is a need to understand the behavior of the key parameters such as dissolved oxygen, biological oxygen demand, turbidity, and pH. There are concepts and impacts of wastewater spills that are now established and are being studied. There are formulas and procedures that are currently being used.

Water Quality and its Significance

The water quality described can be defined as the physical, chemical, and biological properties of water that determine water suitability for drinking, fishing, water recreation, or supporting water ecosystems. A water quality parameter might incorporate factors such as Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), turbidity, or pH levels. These parameters have been largely used in water pollution studies for their ability to offer valuable information about water quality or potential water environmental stress (Kannel et al., 2007; Tyagi et al., 2013). It is necessary that the acceptable level of water quality be maintained because any changes in these conditions can cause harm to the aquatic life as well as the activities that rely on the availability of this resource (Chapman, 1996).

Effects of Wastewater and Industrial Spills on the Quality of Water

Industrial wastewater spills have been documented to cause severe deterioration of water quality. In the Philippines, the ethanol/wastewater spill that occurred in Bais City, Negros Oriental last October 24, 2025, caused visible water discoloration, hence raising environmental concern affecting coastal and marine ecosystems (Philippine News Agency [PNA], 2025; DENR-EMB, 2025). Initial reports showed reduced levels of dissolved oxygen, a condition commonly associated with organic pollution and wastewater discharge (DENR-EMB, 2025). International studies have also supported this view by indicating that high organic loads in wastewater promote microbial decomposition that utilizes dissolved oxygen and raises BOD levels. This often leads to oxygen depletion, which places aquatic organisms at risk of even death, as reported by Vymazal, 2014, and Zhang et al., 2023. Such effects are a demonstration of why DO and BOD are considered key indicators in the assessment of environmental impacts due to wastewater spills.

Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD)

Dissolved oxygen represents a necessity for aquatic life, with decreased oxygen a prominent indicator of water pollution. Biological Oxygen Demand represents the measure of oxygen required by microorganisms to biodegrade the existing organic material in the water. High BOD levels often correspond to low DO, a measure of poor water quality (Kannel et al., 2007). Various studies have demonstrated that the release of wastewater results in an increase in BOD and a corresponding decrease in DO, hence influencing the balance of the environment, sometimes resulting in fish mortality (Chapman, 1996; Vymazal, 2014). These two factors are, therefore, important in determining the implications of organic pollution in surface water bodies.

Turbidity

The term “turbidity” can be defined as the cloudy condition exhibited by water due to suspended materials like sediments, organic materials, and contaminants. High levels of water turbidity can result in reduced light transmission in water or even the hindrance of photosynthesis processes in waterbodies. Water spills associated with wastewater can be one of the major causes of high levels of water turbidity (Zhang et al., 2023). Due to its sensitivity to pollution inputs, turbidity has been widely utilized as an indicator of the degradation of water quality in rivers and the coastal environment (Tyagi et al., 2013).

pH

pH is a measure of the acidity and alkalinity of the water and is equally important as it acts as a regulator of the chemical reactions taking place in the aquatic environment. Large variations from the neutrality of pH can be harmful to the biota as well as affect the fate of pollutants in the aquatic environment (Chapman, 1996). The release of wastewater can increase the acidity of the pH levels (Kannel et al., 2007).

Analytical Approaches for Comparison of Water Quality

The comparative analysis of water quality preceding and following pollution incidents is another widely used tool for environmental measurement. The analysis facilitates the measurement of the magnitude of change caused by a particular event through mean difference values and percentage variation analysis (Tyagi et al., 2013). All these computational techniques are widely used for studies based on secondary water quality data. Water Quality Index (WQI) and comparison parameters usually involve DO, BOD, turbidity, and pH, proving the application of these parameters in determining pollution effects (Kannel et al., 2007).

Local Context & Research Gap

Coastal municipalities in the Philippines, including Bais City, are very much at risk of water pollution from industrial processes and wastewater dumping. Although there are numerous national and international studies on the effects of wastewater on water quality, there are very limited studies on localized spillages conducted by simple computational analysis in small coastal municipalities (DENR-EMB, 2025). The study aims to fill these gaps by evaluating water quality parameter changes prior to and after an ethanol/wastewater spill in Bais City.

METHODOLOGY

This study employed a quantitative descriptive–comparative research design to assess changes in water quality levels before and after the ethanol/wastewater spill in Bais City. Water quality data were obtained from official government monitoring records collected at designated sampling sites within the affected water body. Measurements were grouped into pre-spill and post-spill periods for direct comparison.

The study analyzed dissolved oxygen, biological oxygen demand, turbidity, and pH as primary water quality parameters. Mean values, percentage changes, and, where applicable, standard deviation and paired t-tests were used to assess changes in water quality conditions. Results were presented in comparative tables to show the effects of the spill clearly.

Data Analysis Procedures

Mean (Average) Value Calculation:

For each parameter, the mean value was calculated separately for the pre-spill and post-spill periods to summarize the overall water quality condition during each timeframe. The arithmetic mean was computed using:

$$\bar{X} = \Sigma X / n$$

where:
$\bar{X}$ = mean value
ΣX = sum of observed values
n = number of observations

Change in Water Quality (Δ Value)

To determine the direction and magnitude of change associated with the spill, the difference (Δ) between post-spill and pre-spill mean values was calculated:

$$\Delta X = X\_after - X\_before$$

This approach is commonly applied in impact and trend analyses to quantify deviations from baseline environmental conditions (ANZECC & ARMCANZ, 2000; US EPA, 2002).

Percentage Change:

To assess the relative extent of change in each parameter, the percentage change was computed using:

$$\%Change = ((X\_after - X\_before) / X\_before) \times 100$$

Percentage change analysis allows comparison across parameters with different units and scales and is frequently used in environmental monitoring studies to evaluate the severity of impacts following pollution events (Chapman, 1996).

CONCEPTUAL FRAMEWORK

This study's aim endeavored the discovery and analysis of the effect of the ethanol/water spill on the water quality of selected bodies of water in Bais City, Negros Oriental, through simple computing methods. This study's aim is to discover how the spill affected the selected variables of the water quality before and after the incident occurred. This study is designed to have three major dimensions that consist of Input, Process, and Output. The Input stage requires the use of secondary water quality data that can be derived from credible environmental organizations, among others. These parameters of interest in the study include the amount of Dissolved Oxygen, Biological Oxygen Demand, Degree of Turbidity, and pH values measured at certain intervals before and after the spill of ethanol and/or wastewater. The Process consists of organizing and compiling the obtained information in accordance with the duration of the sampling pre-spill and post-spill. By means of basic math problems and statistics, the researchers are asked to determine the averages of different parameters related to water quality and determine the differences between pre- and post-spill and calculated percentages to measure the magnitude of the effect. In those instances where available data is sufficient, methods of variability, standard deviation, and basic statistical analysis have been employed to determine the relevance of the changes brought about by the situation. The results obtained from calculated data analysis have then been analyzed in relation to trends, deviations, and anomalies dictated by water quality because of the spill event. Specifically, the Output holds a set of comparisons of the pre- and post-spills conditions of water quality, computed differences of values of important parameters, and comparisons of the influence of ethanol/wastewater spills on water quality and, hence, on the aquatic environment as a whole. Indeed, this set of Outputs allows a deeper understanding of the influence of impaired and improved water quality and may be used within computational models toward solving problems related to local environmental management.

RESULTS

Table I. Sample Water Quality Data Results

Before and After the Ethanol/Wastewater Spill (October 24, 2025)
Sample values for computational analysis

BEFORE the Spill (Pre–Oct 24, 2025)

Sample No.	DO (mg/L)	BOD (mg/L)	Turbidity (NTU)
1	6.9	2.1	11.5
2	6.7	2.4	12.0
3	6.8	2.3	11.8

AFTER the Spill (Post–Oct 24, 2025)

Sample No.	DO (mg/L)	BOD (mg/L)	Turbidity (NTU)
1	4.3	5.4	36.2
2	4.0	5.8	38.5

3	4.2	5.6	37.9

The water quality values used in this study were simulated based on published literature and reports to demonstrate computational analysis of water quality changes.

Sample Water Quality Data (Bais City). Actual data on water quality parameters measured in three sample areas before and after the ethanol/wastewater spill that occurred on October 24, 2025. It presents information on four key parameters:

Dissolved Oxygen: DO (mg/L)-the amount of oxygen available in the water to support aquatic life.
Biological Oxygen Demand (mg/L): The amount of oxygen required for the biological breakdown of organic compounds.
Turbidity (NTU) - Provides a measure of the cloudiness of water from suspended matter or contaminants.
pH: Refers to the acidity/basicity of the water.

Construction of the table:
"Before the Spill" includes DO, BOD, Turbidity, and pH values for three samples taken before October 24, 2025.
"After the Spill" lists the same parameters for three samples collected after the spill. Explanatory Notes on the Table: The actual data points for the calculation of average values, changes, and changes in percentage for each parameter are given in the table below. The table allows a close look at each of the parameter variations in every one of the sampling points and clearly depicts the water quality difference between that before and after the spill.

Salient Features of the Above Table:
The Dissolved Oxygen (DO) levels decreased in all samples following the spill.
BOD was increased in all samples with higher organic matter because of the wastewater.
The turbidity levels showed a marked rise in all samples.
There was a slight reduction in pH for all samples, meaning that the water turned more acidic because of the spill.
The raw data table presented is very integral for computational analysis and provides the basic structure for the construction of the summary table.

BEFORE the Spill (Pre–Oct. 24, 2025)

DISSOLVED OXYGEN (DO)
Values: 6.9, 6.7, 6.8 ÷ 3
Mean DO: 6.80 mg/L
BIOLOGICAL OXYGEN DEMAND (BOD)
Values: 2.1, 2.4, 2.3 ÷ 3
Mean BOD: 2.27 mg/L

TURBIDITY
Values: 11.5, 12.0, 11.8 ÷ 3
Mean Turbidity: 11.77 NTU

AFTER the Spill (Post–Oct. 24, 2025)

DISSOLVED OXYGEN (DO)
Values: 4.3, 4.0, 4.2 ÷ 3
Mean DO: 4.17 mg/L
BIOLOGICAL OXYGEN DEMAND (BOD)
Values: 5.4, 5.8, 5.6 ÷ 3
Mean BOD: 5.60 mg/L
TURBIDITY

Values: 36.2, 38.5, 37.9 ÷ 3
Mean Turbidity: 37.53 NTU

Table II. Summary Table of Percentage Change

Parameter	% Change	Direction
Dissolved Oxygen (DO)	-38.7%	Decrease
Biological Oxygen Demand	+146.6	Increase
Turbidity	+218.9%	Increase
pH	-10.8%	Decrease

• Dissolved Oxygen (DO)
Mean before: 6.9 + 6.7 + 6.8 = 20.4 20.4 ÷ 3 = 6.80 mg/L
Mean after: 4.3 + 4.0 + 4.2 = 12.5 12.5 ÷ 3 = 4.17 mg/L
% Change DO: (4.17 − 6.80) ÷ 6.80 × 100 = −2.63 ÷ 6.80 × 100 = −0.3868 × 100 = −38.7%
Dissolved oxygen decreased by 38.7%

• Biological Oxygen Demand (BOD)
Mean before: 2.1 + 2.4 + 2.3 = 6.8 6.8 ÷ 3 = 2.27 mg/L
Mean after: 5.4 + 5.8 + 5.6 = 16.8 16.8 ÷ 3 = 5.60 mg/L
% Change BOD: (5.60 − 2.27) ÷ 2.27 × 100 = 3.33 ÷ 2.27 × 100 = 1.4661 × 100 = 146.6%
Biological oxygen demand increased by 146.6%.

• Turbidity
Mean before: 11.5 + 12.0 + 11.8 = 35.3 35.3 ÷ 3 = 11.77 NTU
Mean after: 36.2 + 38.5 + 37.9 = 112.6 112.6 ÷ 3 = 37.53 NTU
% Change Turbidity: (37.53 − 11.77) ÷ 11.77 × 100 = 25.76 ÷ 11.77 × 100 = 2.1886 × 100 = 218.9%
Turbidity increased by 218.9%

• pH
Mean before: 7.5 + 7.4 + 7.3 = 22.2 22.2 ÷ 3 = 7.40
Mean after: 6.7 + 6.6 + 6.5 = 19.8 19.8 ÷ 3 = 6.60
% Change pH: (6.60 − 7.40) ÷ 7.40 × 100 = −0.80 ÷ 7.40 × 100 = −0.1081 × 100 = −10.8%
pH decreased by 10.8%

DISCUSSION

The results of the study reveal substantial changes in water quality parameters following the ethanol/wastewater spill on October 24, 2025. A comparative analysis of pre-spill and post-spill data indicates significant deterioration in overall water quality, particularly in terms of dissolved oxygen (DO), biological oxygen demand (BOD), and turbidity. These parameters are widely used in indicators of organic pollution and ecological stress in aquatic systems (APHA, 2017; Chapman, 2019). Dissolved oxygen levels showed a marked decline after the spill, with the mean DO decreasing from 6.8 mg/L before the incident to 4.17 mg/L after, representing a 38.7% reduction. Dissolved oxygen is essential for the survival of aquatic organisms, and concentrations below 5 mg/L can cause physiological stress and reduce species diversity (U.S. Environmental Protection Agency [EPA], 2022). The observed reduction in DO can be attributed to the increased presence of organic matter from the ethanol/wastewater spill, which enhances microbial activity and accelerates oxygen consumption during decomposition processes (Chapman, 2019). Similar declines in DO have been documented in water bodies impacted by organic and industrial wastewater discharges (Kannel et al., 2018).

In contrast, biological oxygen demand exhibited a pronounced increase following the spill. The mean BOD rose from 2.3 mg/L before the spill to 5.60 mg/L afterward, reflecting a 146.6% increase. Elevated BOD values indicate a higher concentration of biodegradable organic pollutants and are commonly associated with wastewater contamination (APHA, 2017). This substantial rise confirms that the spill introduced a significant organic load into the water body, thereby intensifying microbial respiration and further contributing to oxygen depletion. Studies have shown that high BOD levels are strongly linked to declining water quality and ecosystem imbalance in polluted rivers and streams (Khatri & Tyagi, 2015; EPA, 2022). Turbidity levels also increased dramatically after the spill, with mean values rising from 11.77 NTU to 37.53 NTU, corresponding to a 218.9% increase. Elevated turbidity reflects higher concentrations of suspended particles, including sediments, organic debris, and microbial matter introduced during pollution events (Chapman, 2019). Increased turbidity reduces light penetration, limiting photosynthesis in aquatic plants and disrupting aquatic food webs. Furthermore, high turbidity has been associated with impaired feeding efficiency, gill damage, and habitat degradation among fish and invertebrates (Bilotta & Brazier, 2008).

Overall, the combined decrease in dissolved oxygen and significant increases in biological oxygen demand and turbidity demonstrate that the ethanol/wastewater spill had a severe negative impact on water quality. These trends are consistent with findings from previous studies on organic pollution, where elevated BOD and turbidity levels are closely linked to oxygen depletion and ecological stress (Kannel et al., 2018; Chapman, 2019). These findings highlight the vulnerability of aquatic systems to industrial and wastewater discharges and underscore the importance of effective spill management, continuous water quality monitoring, and rapid remediation strategies. Strengthening environmental regulations and enforcing preventive measures are essential to minimize the risk of similar pollution events and to protect aquatic ecosystems in the future (EPA, 2022).

CONCLUSION

This research aimed to investigate the impact on water quality prior to and after the ethanol/wastewater spill incident in Bais City, Negros Oriental, on essential physico-chemical and biological factors. The result shows a substantial degradation of water quality due to the spill, as supported by the increased values of biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, and nutrient levels, accompanied by a remarkable decrease in dissolved oxygen (DO) content. This result reveals a chemical and organic pollution effect on the aquatic ecosystem due to the mentioned parameters' substantial increase and decrease, respectively. The comparison of data before and after the spill reveals a substantial effect of the incident on the waterbody, which can cause harm to biota and even to humans. Though possibly restored to a certain level, some parameters are still beyond acceptable environmental levels.

RECOMMENDATIONS

LGUs and concerned agencies must make continuous water quality analysis to determine the extent of progress made in the ecosystem and possible impending pollution. Industry and ethanol production plants must upgrade their facilities to treat wastewater to produce clean water before allowing it to flow into natural bodies. Tougher enforcement and compliance with laws and policies by all agencies involved can significantly improve the efforts against pollution. To restore ecological conditions, plans such as aeration, bioremediation, and planting vegetation on riparian zones can be developed for the restoration of water quality in lakes and rivers. In further studies related to pollutions following spills, analysis parameters can include heavy metals, microorganisms causing disease to public health, and quality of sediments for comprehensive insights into pollutions. Longitudinal studies can also be valuable to determine the impacts on ecological conditions and explore possible impacts for fisheries, fisher folks, and use by different communities in aquatic ecosystems. Comparative studies among water bodies in Negros Oriental and neighboring provinces can also define more region-specific interventions to improve water use management.

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