DEVELOPMENT OF A WATER QUALITY PREDICTION MODEL THROUGH THE UTILIZATION OF SOLAR-POWERED PHYTOREMEDIATION WATER TREATMENT POOL IN IMPROVING THE WATER QUALITY OF PANDURUCAN RIVER, SAN JOSE, OCCIDENTAL MINDORO

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ABSTRACT

The Pandurucan River is vital for agriculture, fisheries, and domestic use in San Jose, Occidental Mindoro. However, it is currently suffering from severe water quality issues caused by pollution from surrounding agricultural and residential lands. To improve its water quality, Scatter Linear Regression, Analytic Hierarchy Process (AHP), and ArcGIS were utilized in this research to develop a water quality prediction model, analyzing the significant parameters such as temperature, pH, dissolved oxygen, chloride, TSS, nitrate, and phosphate. The Water Quality Guidelines and Effluent Standards of 2016 (DAO 2016-08) were followed during the water quality monitoring, and the Analytic Hierarchy Process (AHP) was used to determine parameter weights for map generation. This water quality assessment revealed high chloride and phosphate level contents, low dissolved oxygen, and saltwater intrusion, where all stations failed in the Water Quality Index (WQI), particularly in Brgy. San Roque. Further, the Solar-Powered Phytoremediation Water Treatment Pool efficiently improved all water quality parameters, as visualized in the ArcGIS-based model. This result was validated using the R-squared (R^2) method, which ensured that the prediction model efficiently captured water quality variations, being a reliable tool for environmental management.

Keywords: *analytical hierarchy process, effluent standards, geographical information system, water quality prediction model, water quality guidelines, water quality parameters*

SDG: *SDG 6: Clean Water and Sanitation, SDG 13: Climate Action*

INTRODUCTION

Water pollution remains a global concern due to population growth, urbanization, and industrialization. The disposal of untreated wastes from industries, agriculture, and households damage the ecosystem, disease transmission, and water scarcity (Md Anawar & Chowdhury, 2020). The survey conducted by United Nations Environment Programme in 89 countries, revealed that over 40 percent of the 75,000 water bodies were severely polluted (Murray, 2021). Considering the increasing demand for water worldwide, it is a pressing need to focus on the importance of water management through sustainable water and wastewater treatment.

Water pollution in the Philippines threatens the health, the economy and the environment. Half of the country's drinking water comes from the 421 rivers and 221 lakes and 43% of the country's rivers and 56% of the country's major water bodies are considered polluted (Philippine Institute for Development Studies, 2024). Thus, led to the implementation of the Philippine Clean Water Act of 2004 were community-driven initiatives were laid out to improve the water quality (Republic Act No. 9275, 2004).

Locally, Pandurucan River, one of the 11 rivers traversing in San Jose, Occidental Mindoro has been showing signs of pollution due to the improper waste disposal practices of the surrounding community (Muyot, 2022). The water quality monitoring conducted in Pandurucan River discovered the poor water quality index and was considered unsuitable for recreational activities. Further, the river is considered impaired and deteriorating from the industrial discharges, poor waste management, and agricultural runoff (Enriquez & Tanhueco, 2022). As the rehabilitation of the Pandurucan River becomes a priority project of the Local Government Unit of San Jose, efforts are laid out to realize the revival of the Pandurucan River.

One particular rehabilitation technique for water bodies is the remediation process, a measure taken by water utilities to restore safe and regular service after contamination and ensure that water is safe for public use and the environment (U.S. Environmental Protection Agency, 2021). Effective remediation requires the identification of the contaminant, the behavior of the spread, and the application of suitable treatment methods to eliminate the threat and prevent long-term damage (Padhye et al., 2023). Phytoremediation is an innovative and sustainable method for rehabilitating environments contaminated by heavy metals and pollutants, particularly in water bodies (Pang et al., 2023). This eco-friendly approach harnesses the natural capabilities of specific plants to absorb harmful substances from their surroundings and, in return, release non-toxic byproducts into the ecosystem (Verma & Jadhav, 2021). Among the various techniques utilized in phytoremediation, using aquatic plants as biofilters has shown significant promise for effective water treatment (Gorito et al., 2017). Research indicates that free-floating aquatic plants such as water hyacinth, water ferns, duckweeds, water lettuce, and watercress possess remarkable properties that enable them to extract heavy metals from polluted environments. These plants draw metals through their root systems, facilitating the passive transport of contaminants upwards within the plant structure, ultimately leading to their accumulation in the upper parts of the plant (Priya et al., 2023).

Furthermore, water quality prediction plays an important role in protecting water resources and addressing the growing water crisis; the intelligent algorithms provided as the prediction model enable proactive measures for pollution prevention, better water management, and informed decision-making (Wu et al., 2022). Additionally, Geographic Information Systems (GIS) have proven effective in analyzing water quality data (DeepChand et al., 2022). This study explored these advanced approaches as valuable tools for characterizing both current and future water quality.

As an important river in San Jose, Occidental Mindoro, Pandurucan River receives concern on reviving the water quality of the recreational water. The Municipal Environment Office of the local government of San Jose had prioritized the Rehabilitation project of the Pandurucan River. As the unit is formulating its water rehabilitation plan for the Pandurucan River, this study could provide substantial information on implementing cost-effective and sustainable strategies. This study offers sustainable strategies that could be presented to the local government to improve the quality of the Pandurucan River. The water quality analysis performed in the study can serve as the backbone of the rehabilitation plan; the developed solar-powered phytoremediation water treatment pool is the cost-effective approach, while the water quality prediction model as part of the sustainable plan in safeguarding the water quality of Pandurucan river. The water quality monitoring plan guided the researchers in the water sampling testing, and analysis of the results was modeled in ArcGIS to determine the behavior of contaminants before and after the implementation of the phytoremediation process.

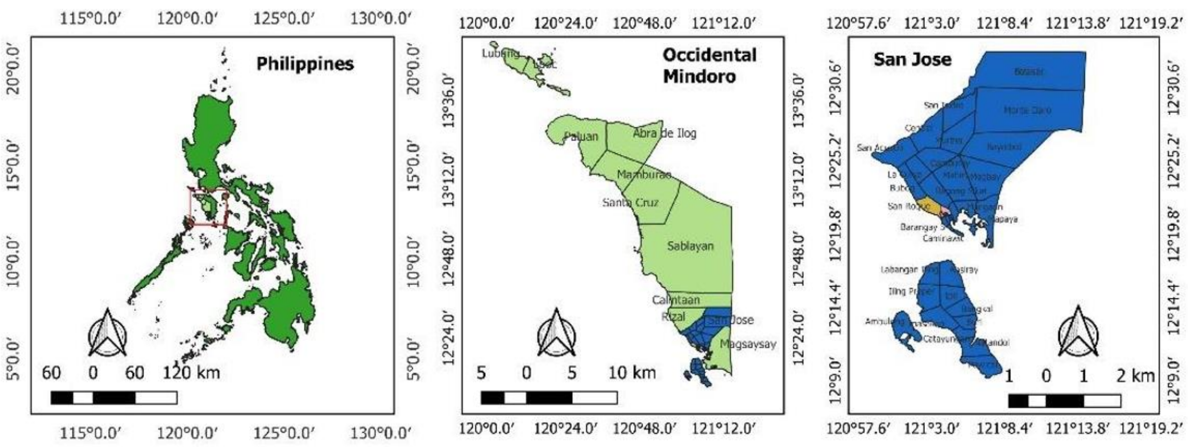
METHODS

Research Design

The research design of the study applied the quantitative method by incorporating both assessment and experimental methods to evaluate the water quality of the Pandurucan River. It focused on monitoring water quality parameters before and after the installation of phytoremediation water treatment pool to determine its effectiveness following the DENR-EMB DAO 2016-08 and utilized ArcGIS for spatial modeling and analysis of the data collected from the sampling stations.

Study Site

The study conducted within the span of Pandurucan River. Figure 2 shows the four identified sampling locations used in the study.



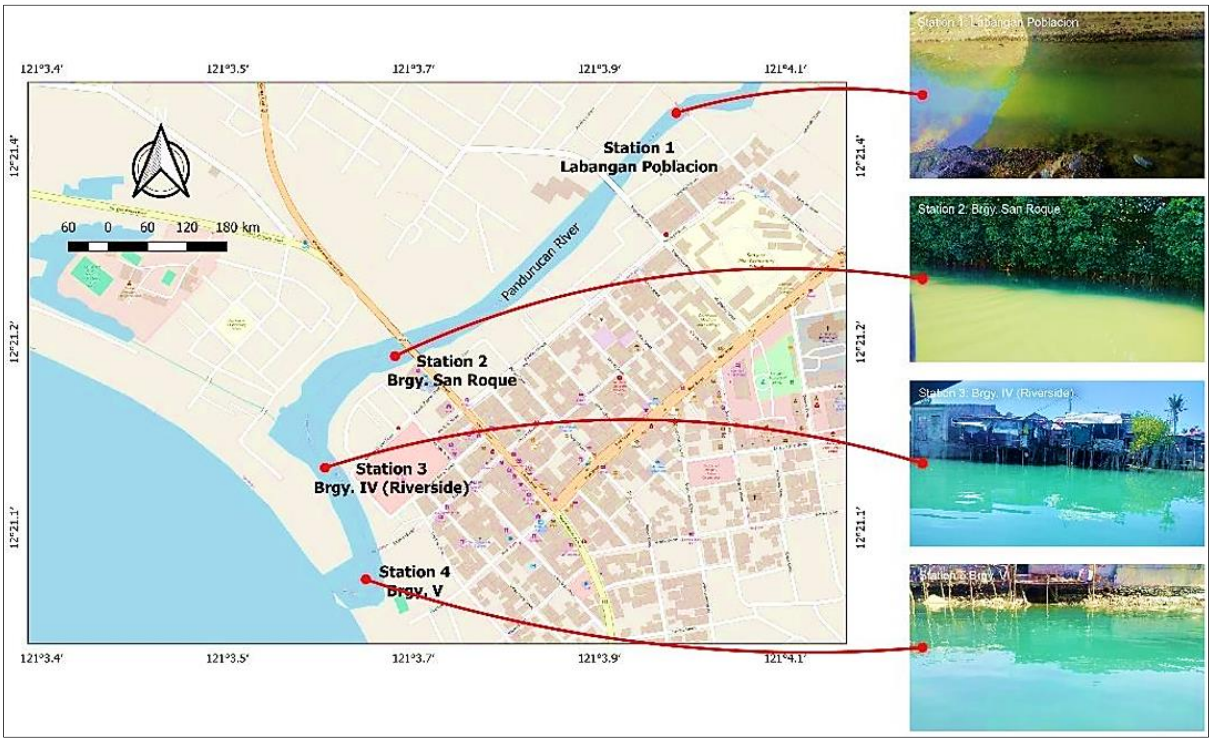


Fig. 1. Map of the Pandurucan River with four identified sampling locations generated from QGIS 3.36.1.

The study covered the upstream, midstream, and downstream sections of the Pandurucan River, with four sampling stations identified for water collection and analysis. The stations were strategically selected based on river classification: Labangan as the upstream section, Barangay San Roque and Barangay IV as the midstream, and Barangay V as the downstream where the river water merges with saltwater. Table 1 shows the location of the sampling site as well as its description.

Table 1. Description and profile of sampling sites.

Stations	Description
Station 1: Labangan, Poblacion	The station is located 12°21'27"N 121°03'58"E at Labangan, San Jose, Occidental Mindoro; located near the mangrove areas and riverbanks; with surrounding areas for agriculture and some commercial and residential areas.
Station 2: San Roque	Station 2, located at 12°21'14"N, 121°03'44"E in Barangay San Roque, San Jose, Occidental Mindoro, situated near the Pandurucan Bridge. The area surrounding the station, including the river and its banks, have scattered garbage along the mangroves.

Station 3: Barangay IV (Riverside)	Station 3, located at 12°21′07″N, 121°03′37″E in Barangay IV, San Jose, Occidental Mindoro, is at riverside area surrounded by residential and commercial buildings. The water has visible garbage, greenish-brown water, and a foul smell with riverbed covered by muddy clay.
Station 4: Barangay V	The station 4 is at 12°21′02″N, 121°03′40″E in Barangay 5, San Jose Occidental Mindoro surrounded by residential, commercial, and agricultural land. The river water has garbage along the banks with muddy and brownish water.

Sample Collection

The study used manual sampling and grab water samples, as the Pandurucan River was not wadable. One sample was collected from each of the four stations between January 24 and February 7, 2025, excluding rainfall events, and following DAO 2016-08 guidelines. Sampling took place from 10:00 AM to 12:00 PM.

Water samples for chloride, TSS, nitrate as NO_3-N, and phosphate were collected and brought to the accredited Department of Health (DOH) Laboratory for physicochemical analysis at First Analytical Services and Technical Cooperative (FAST Laboratories) located in Brgy. San Rafael, Santo Tomas, Batangas. Water samples were placed on the container and kept in a cool box at about 6 °C as recommended by the laboratory.

Furthermore, after fabricating the prototype, the installation followed, and the location was determined using the calculated WQI. Water lettuce was selected for phytoremediation and placed in the prototype after proper cleaning. Water quality was monitored, with samples collected and analyzed from February 20 to March 5, 2025.

Sample Analysis

In the analysis of grab water samples, both in-situ measurements and laboratory analysis were employed to obtain comprehensive data about the water quality. The parameters temperature, pH level, and DO were taken in-situ analysis using the digital DO Meter while parameters chloride, TSS, nitrate as NO3-N, and phosphate were analyzed in laboratory.

Design and Development of the Solar-Powered Water Treatment Pool

The design of the solar-powered phytoremediation water treatment pool was made using AutoCAD which incorporated structural, electrical, and phytoremediation components for the effective and sustainable water treatment of the Pandurucan River. The structure of the prototype was designed as an octagonal cylindrical framework built through welded reinforced tubular steel and steel bars. On the other hand, its electrical system includes a 120W solar panel mounted on a metal frame to maximize sunlight exposure and to power a solar charge controller, a 12V lead-acid battery, and a 12V-500W inverter, enabling the operation of a smart water quality sensor that records real-time water conditions. For the phytoremediation, 40 medium-sized water lettuce plants were collected, cleaned, and placed in the pool at a moderate biomass density.

Ethical Consideration

The researchers followed all the necessary guidelines to ensure the study was carried out responsibly and ethically. The permission was obtained from the barangay before the installation of the water treatment pool. Moreover, all procedures involving water collection and analysis were performed in compliance with established environmental regulations and standards, ensuring the integrity and safety of the research process. The aquatic plants used for the treatment were responsibly sourced, and the study did not harm the river or its surroundings. The researchers ensured data accuracy, kept necessary information confidential, and presented the results transparently throughout the research.

Data Analysis

The researchers used the Canadian Council of Ministers of the Environment (CCME) method to calculate the WQI for each station to identify the most polluted sampling location after using the digital water quality meter and conducting the laboratory analysis. The station with the lowest WQI score was chosen as the site for the installation of the Solar-Powered Water Treatment Pool. The t-test was performed through comparing the water quality data before and after the installation to determine the effectiveness the water treatment pool. A p-value below 0.05 indicated that the treatment had a measurable effect.

The study also use the Geographic Information System (GIS) tools, scatter linear regression, and the Analytical Hierarchy Process (AHP). The water quality and prediction models were developed both before and after the phytoremediation process using ArcGIS 10.7.1. The regression analysis was used to forecast water quality trends over a five-year period. Meanwhile, AHP helped determine the weight or importance of each water quality parameter by consulting experts from the local sanitary office, barangay health officials, and representative from the Prime Water. The experts compared each parameter using Saaty's 1–9 scale to reflect its relative importance in evaluating water quality.

RESULTS

Water Quality Parameters Testing Results

Following the water quality monitoring plan presented in Chapter 3, the sampling methodology was carefully conducted, and all measured values were recorded and analyzed. The results of water samples taken from the four (4) designated sampling stations from January 14, 2025 to February 7, 2025.

Figure 2 shows the varying results of the water quality parameters across the four sampling stations. Temperature ranged from 28.60°C to 31.80°C, with some readings exceeding the DAO 2016-08 standard of 26°C to 30°C. The pH levels ranged from 6.65 to 8.26, indicating alkaline water. DO levels were mostly below the 5 mg/L standard, with Brgy. V recording the highest levels, suggesting better water quality, while Brgy. San Roque had the lowest levels, indicating pollution and reduced oxygen due to slower water flow and higher temperatures. Chloride concentrations exceeded the 250 mg/L limit at all stations due to saltwater intrusion, with Brgy. V having the highest levels. TSS remained within the 65 mg/L limit, with Brgy. IV showing the highest TSS. The nitrate as NO_3–N levels were within the 7 mg/L limit, with Brgy. IV having the highest concentration of 0.30 mg/L while phosphate levels exceeded the 0.5 mg/L standard at all stations, with Brgy. Labangan recording the highest value.

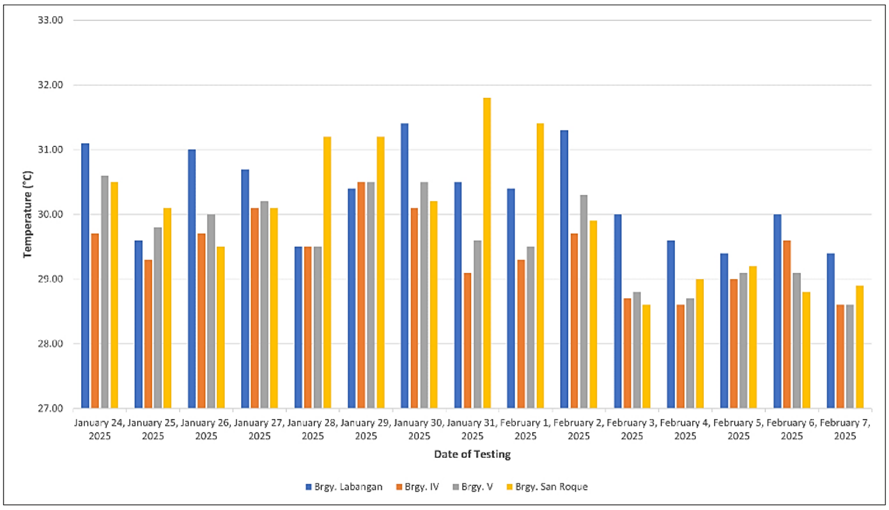


Fig. 2a. Temperature before the phytoremediation treatment

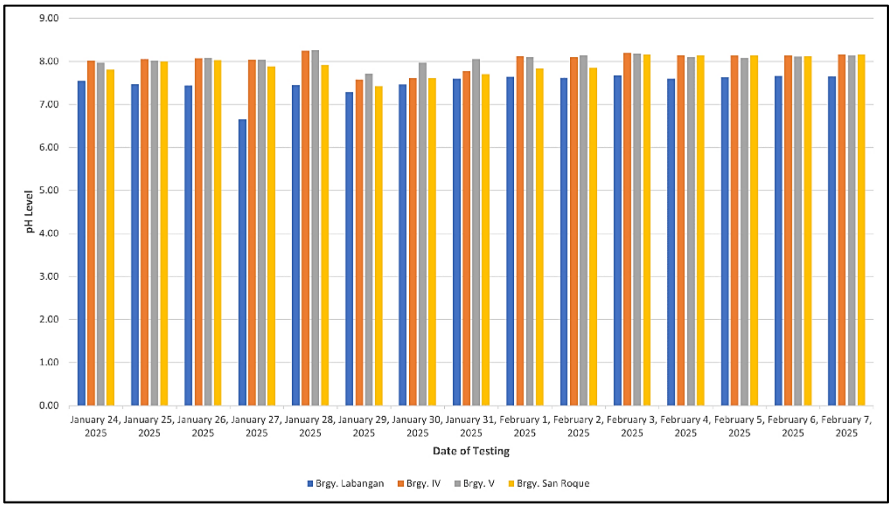


Fig. 2b. pH level before the phytoremediation treatment

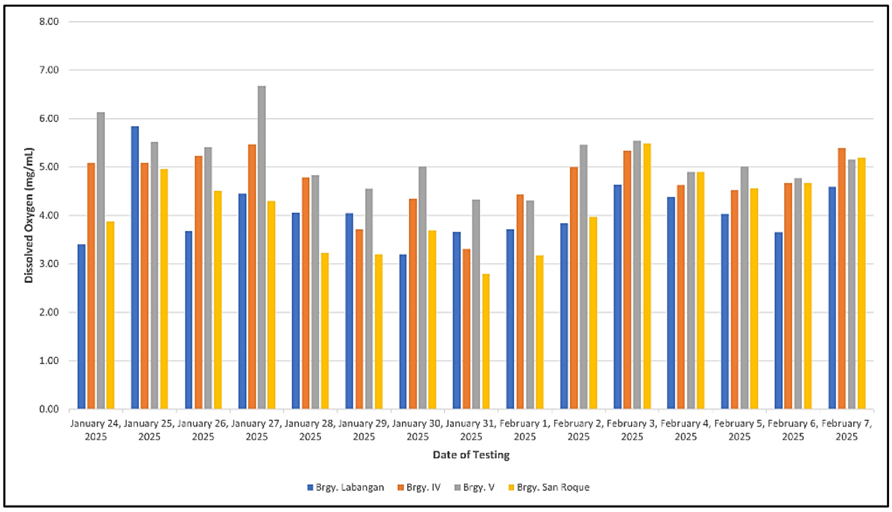


Fig. 2c. Dissolved oxygen before the phytoremediation treatment.

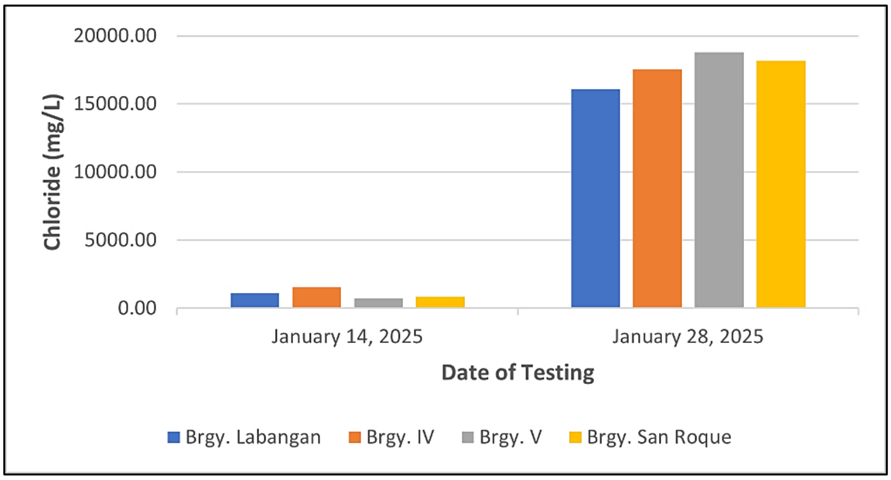


Fig. 2d. Dissolved oxygen before the phytoremediation treatment.

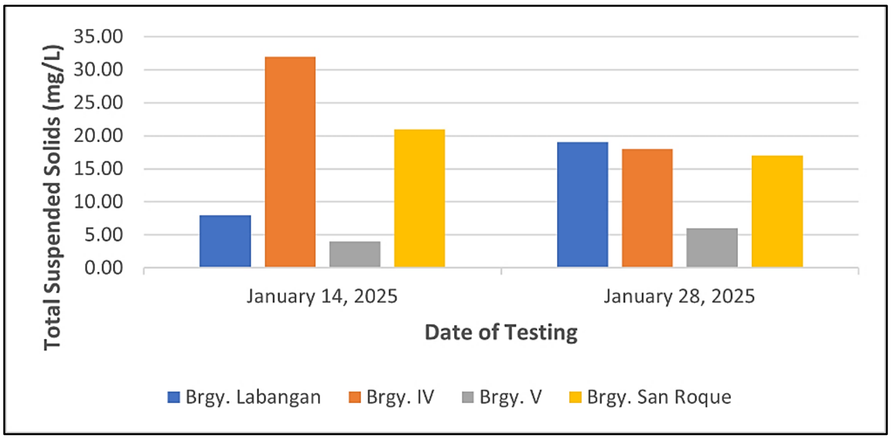


Fig. 2e. Dissolved oxygen before the phytoremediation treatment.

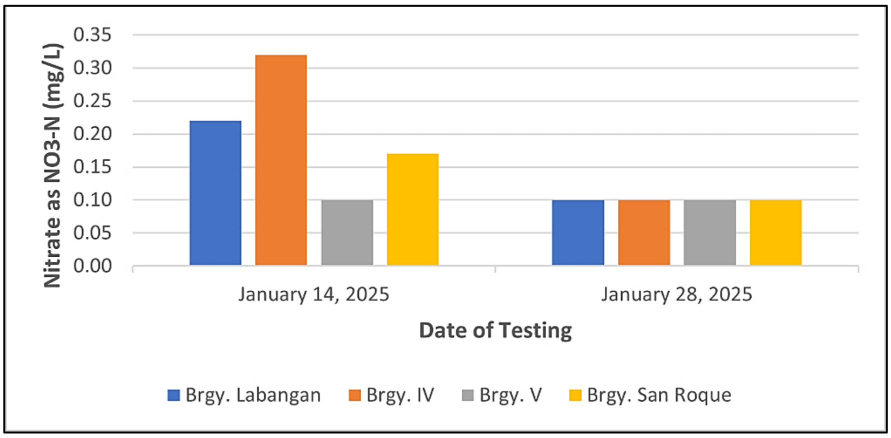


Fig. 2f. Nitrate as NO3-N before the phytoremediation treatment.

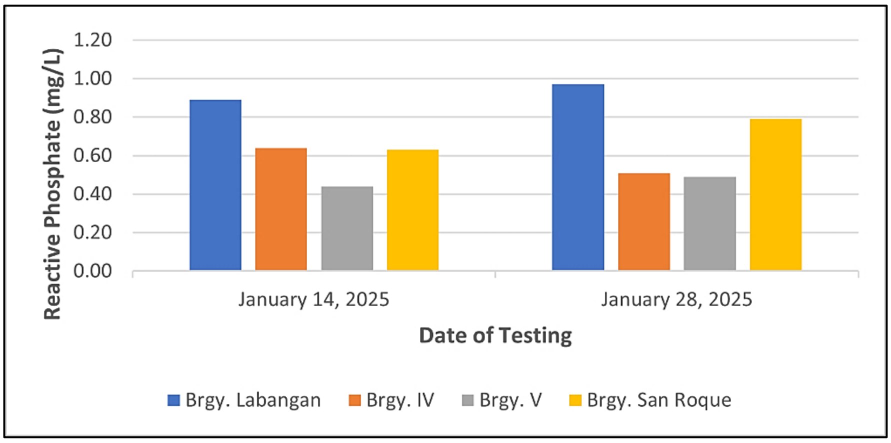


Fig. 2g. Reactive phosphate before the phytoremediation treatment.

Water Quality Index Values

After analyzing the water samples, the researchers determined the WQI for each sampling station using the CCME method. The assessment integrated the water quality parameters into a single index value to reflect the overall water quality.

Table 8 shows the computed WQI for all four stations indicated poor water quality. The results suggested that the Pandurucan River is consistently threatened by environmental factors. Among the sampling stations, Brgy. San Roque has the lowest WQI, indicating having the poorest water quality.

Table 8. Water Quality Index of the four sampling stations.

Sampling Stations	Computed WQI	Rank	Description
Labangan	28.8328	Poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels
San Roque	27.6342	Poor	
Brgy IV.	33.9890	Poor	
Brgy V.	41.4606	Poor	

Water Quality Testing Results with Phytoremediation Water Treatment Pool

After identifying the most polluted station, the water treatment pool was installed, and phytoremediation plants were added on February 18, 2025. Water quality analysis was conducted from February 20 to March 5, 2025, with in-situ tests for temperature, pH, and dissolved oxygen. Samples for chloride, TSS, nitrate (NO3–N), and phosphate were collected on February 27, 2025, and analyzed in the laboratory.

Figure 3 shows the result of the water quality monitoring after the installation of the water treatment pool at the Brgy. San Roque. The temperature remained stable between 27.9°C and 29.4°C. The pH stayed slightly alkaline, ranging from 7.4 to 7.83, and dissolved oxygen (DO) improved, meeting DAO 2016-08 standards. However, chloride levels at 16,600 mg/L still exceeded the standard. TSS and nitrate values were within the allowable limits of 14 mg/L and 7 mg/L, respectively, and phosphate levels were safe at 0.40 mg/L. The t-test confirmed significant improvements in DO ($p = 0.00003$), pH ($p = 0.007$), and temperature ($p = 0.0008$), demonstrating the effectiveness of the phytoremediation pool.

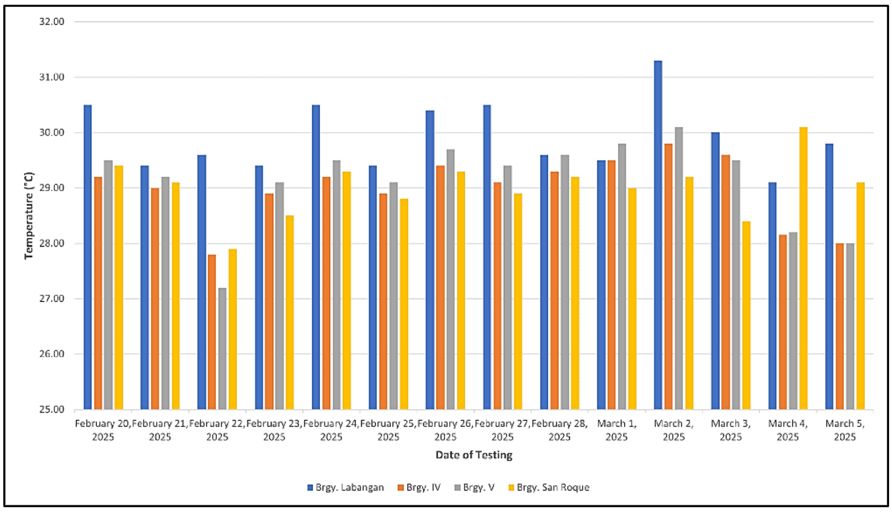


Fig. 3a. Temperature after the phytoremediation treatment.

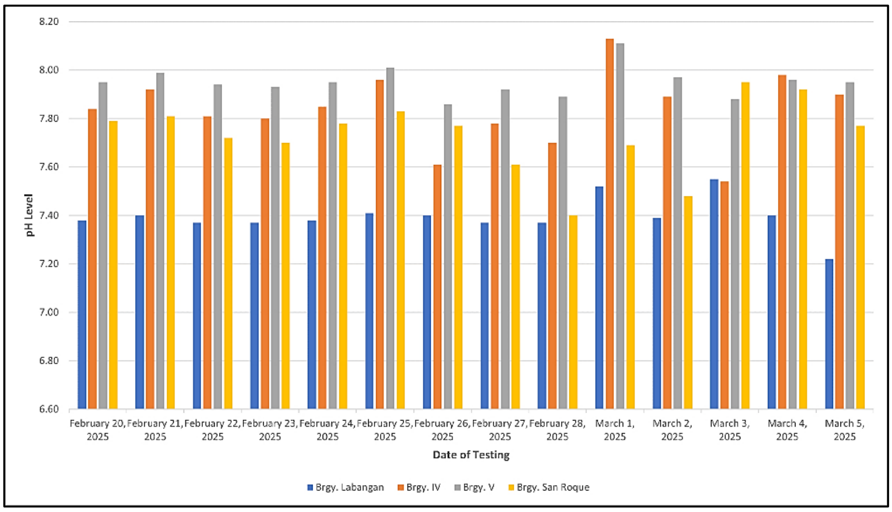


Fig. 3b. pH level after the phytoremediation treatment.

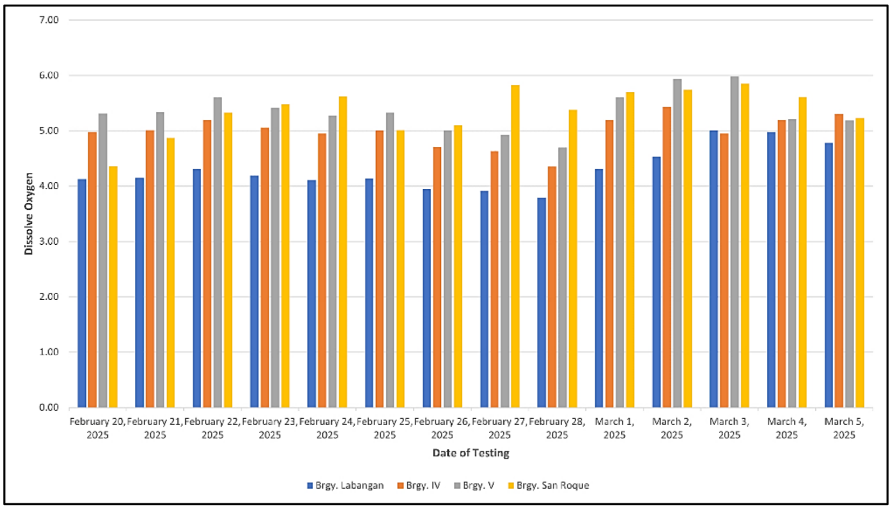


Fig. 3c. Dissolved oxygen after the phytoremediation treatment.

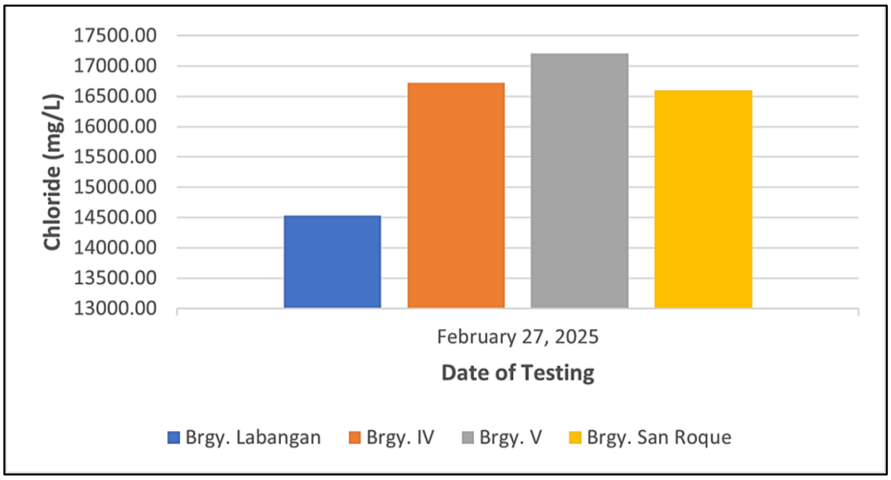


Fig. 3d. Chloride after the phytoremediation treatment.

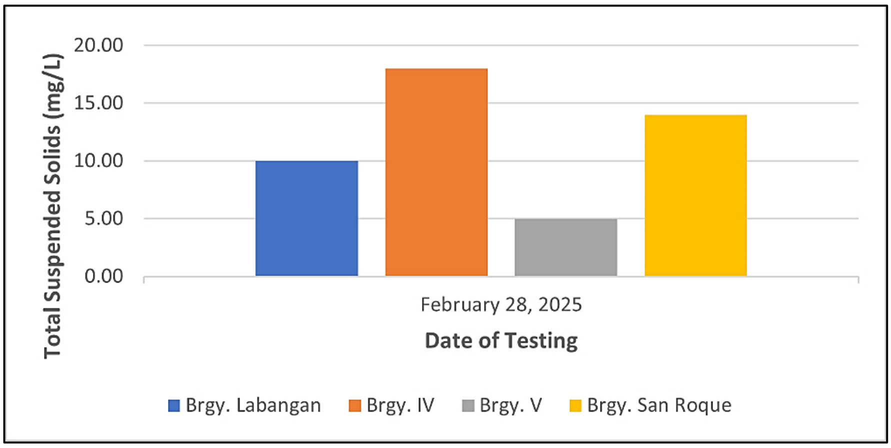


Fig. 3e. Total suspended after the phytoremediation treatment.

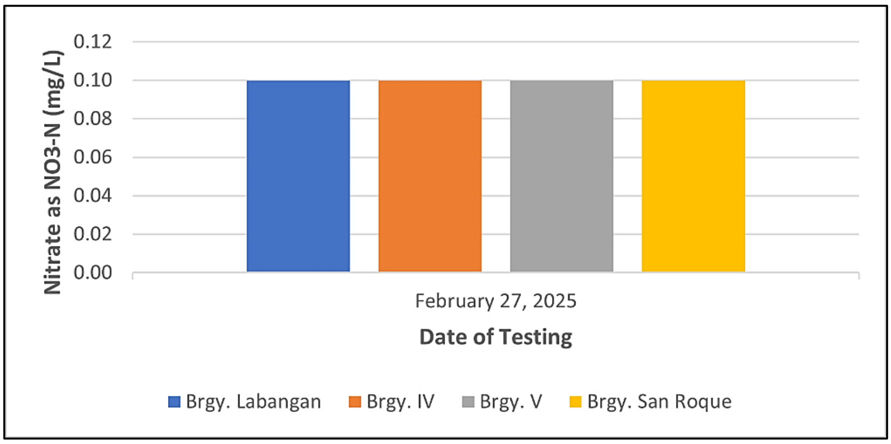


Fig. 3f. Nitrate as NO3-N after the phytoremediation treatment.

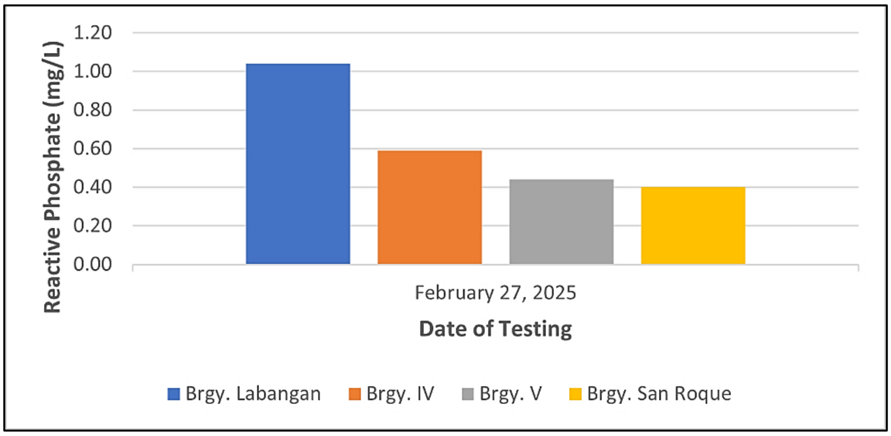
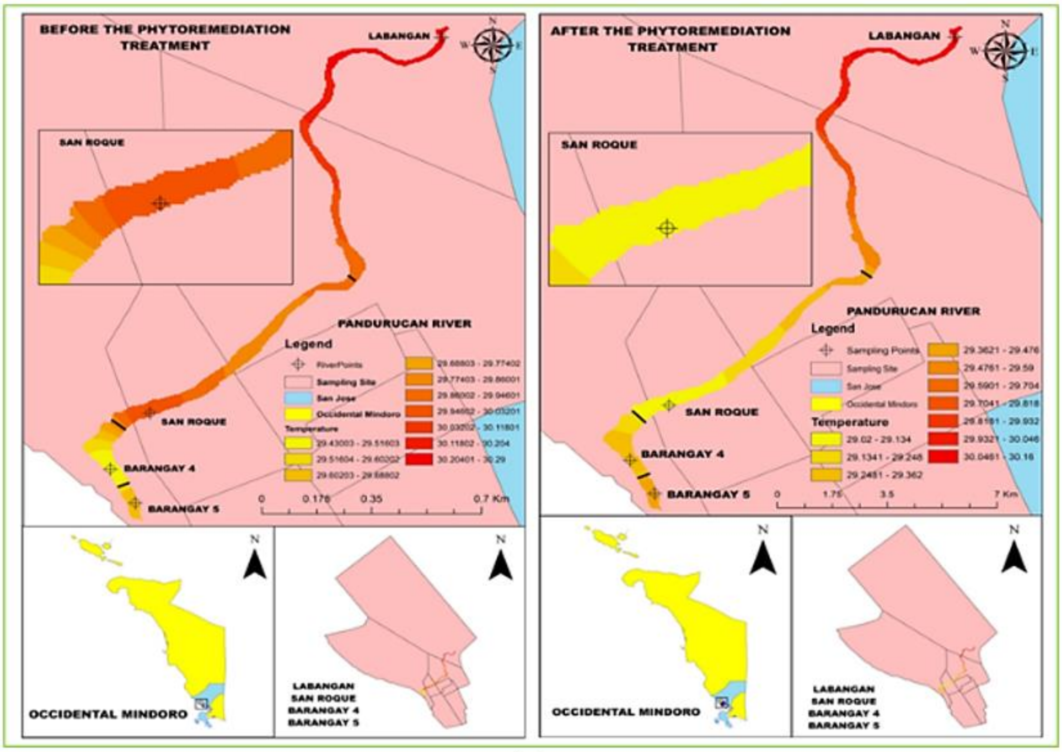


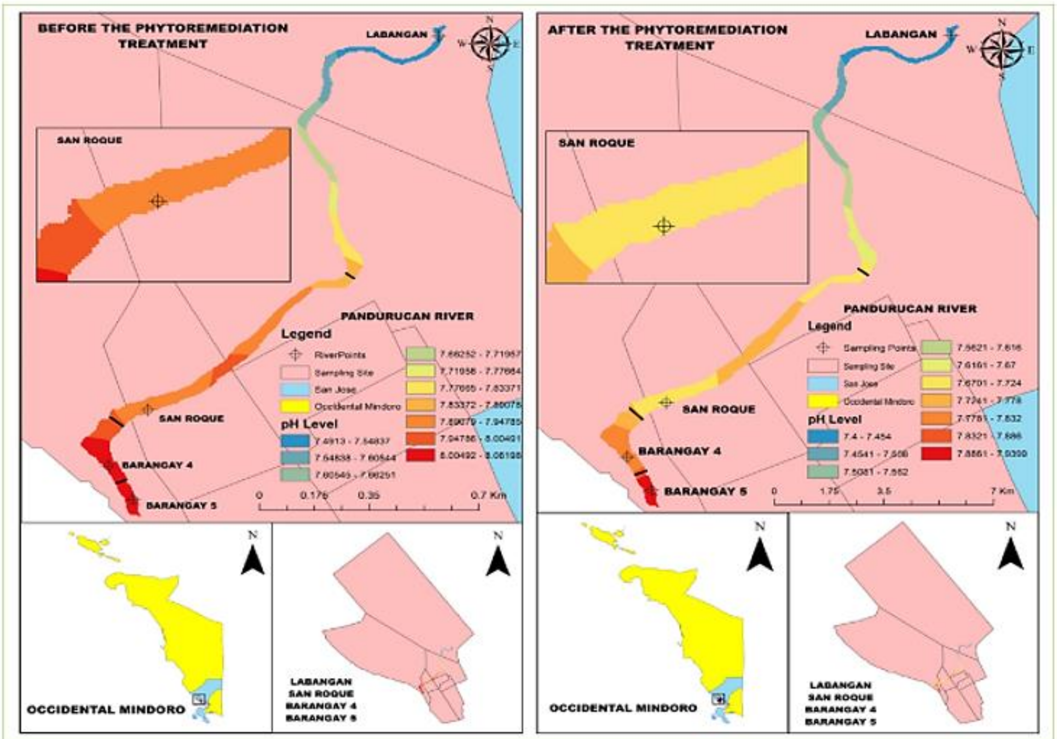
Fig. 3g. Reactive phosphate after the phytoremediation treatment.

Water Quality Models

The water quality before and after the installation of phytoremediation pool in San Roque was analyzed using ArcGIS with the IDW interpolation method, generating spatial maps to visualize changes across all sampling stations and exhibited the following results.



(a)



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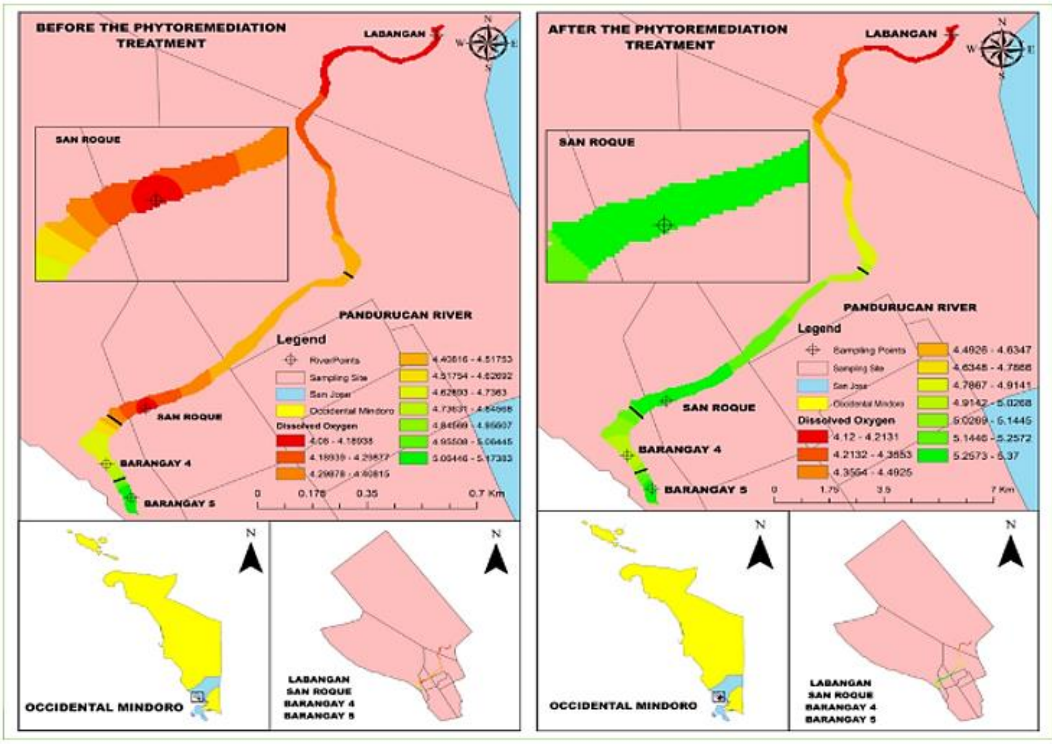
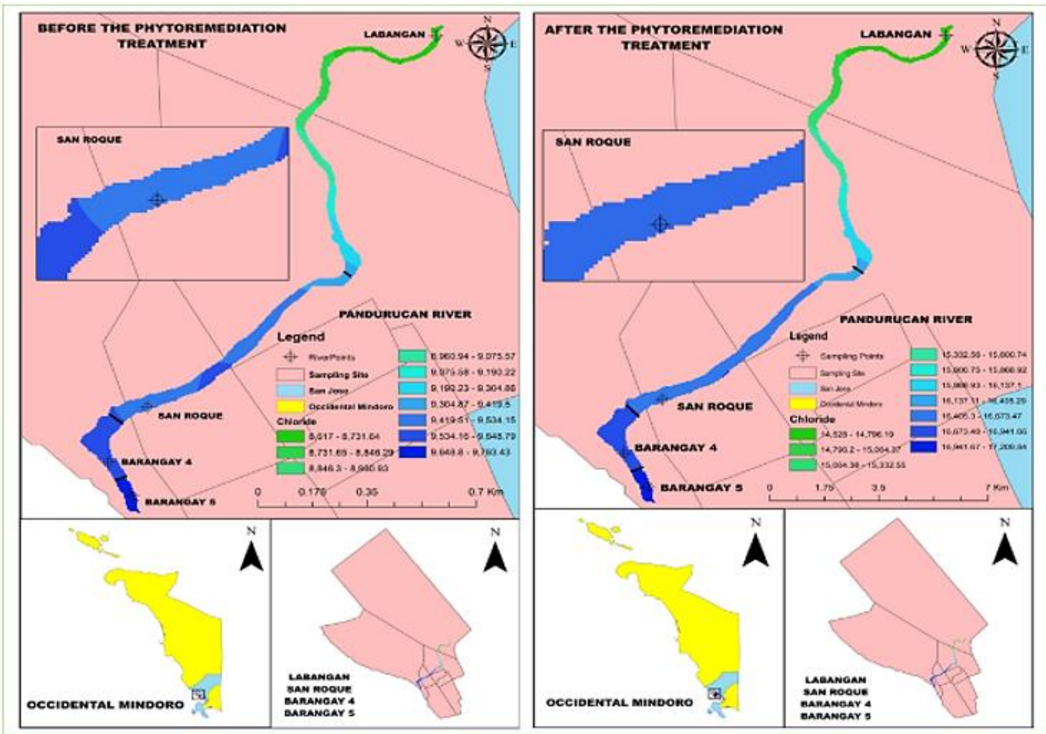

BEFORE THE PHYTOREMEDIATION TREATMENT
LABANGAN
SAN ROQUE
PANDURUCAN RIVER
Legend
Dissolved Oxygen
SAN ROQUE
BARANGAY 4
BARANGAY 5
AFTER THE PHYTOREMEDIATION TREATMENT
LABANGAN
SAN ROQUE
PANDURUCAN RIVER
Legend
Dissolved Oxygen
SAN ROQUE
BARANGAY 4
BARANGAY 5
OCCIDENTAL MINDORO
LABANGAN
SAN ROQUE
BARANGAY 4
BARANGAY 5
OCCIDENTAL MINDORO
LABANGAN
SAN ROQUE
BARANGAY 4
BARANGAY 5

(c)


BEFORE THE PHYTOREMEDIATION TREATMENT
LABANGAN
SAN ROQUE
PANDURUCAN RIVER
Legend
Chloride
SAN ROQUE
BARANGAY 4
BARANGAY 5
AFTER THE PHYTOREMEDIATION TREATMENT
LABANGAN
SAN ROQUE
PANDURUCAN RIVER
Legend
Chloride
SAN ROQUE
BARANGAY 4
BARANGAY 5
OCCIDENTAL MINDORO
LABANGAN
SAN ROQUE
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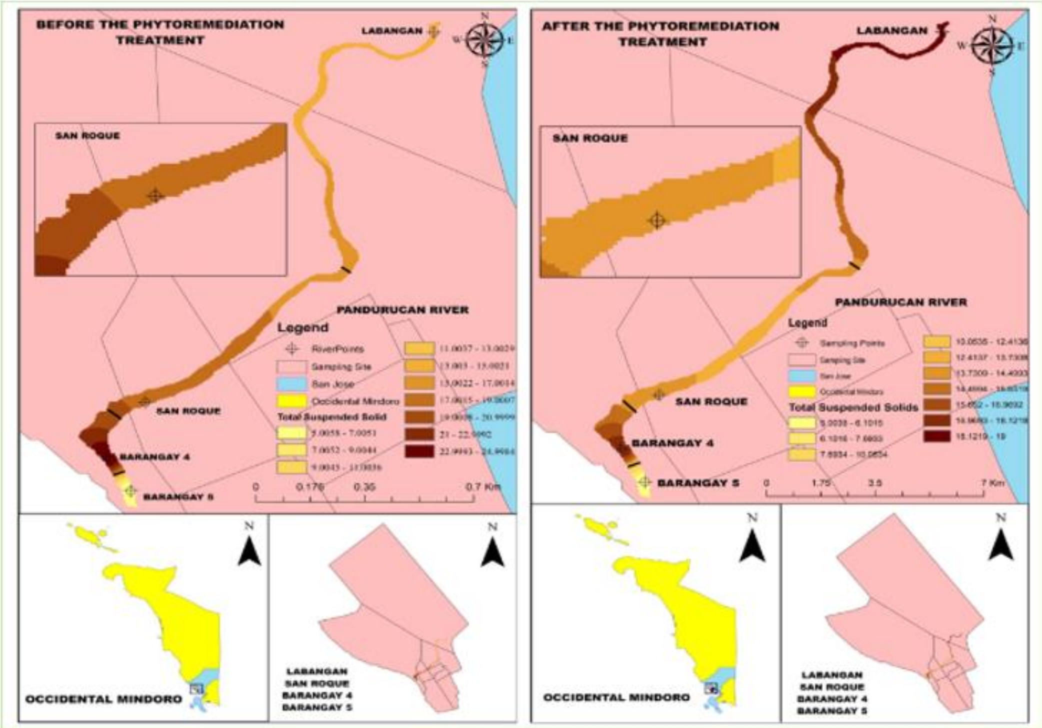
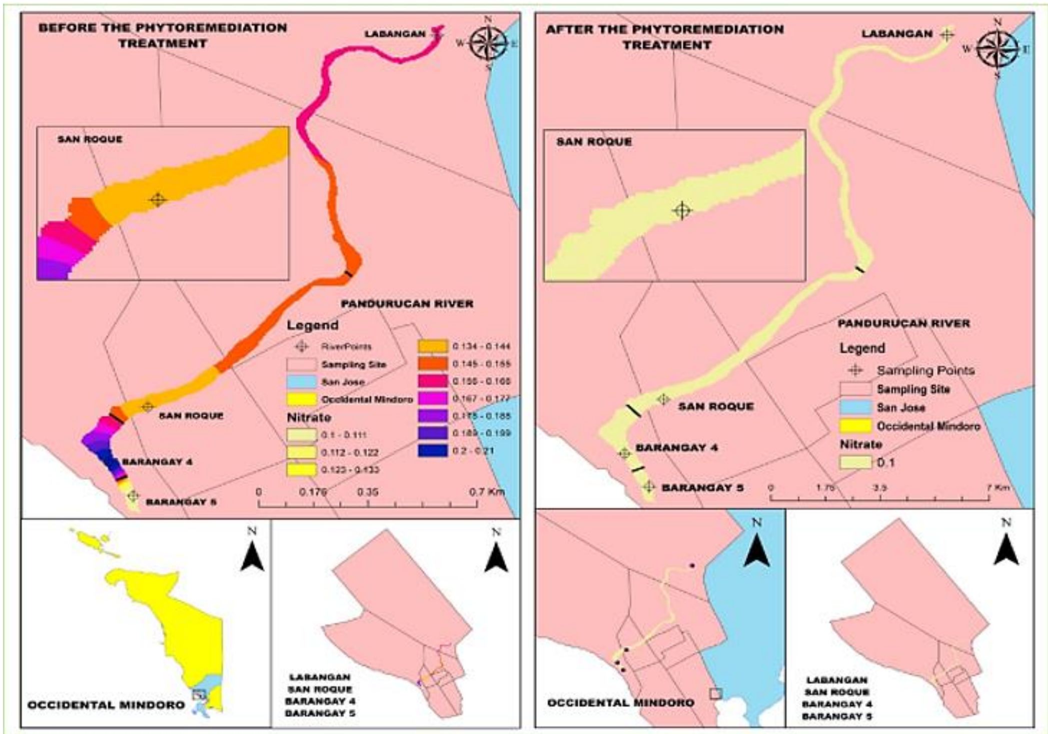
LABANGAN
SAN ROQUE
BARANGAY 4
BARANGAY 5

(d)


BEFORE THE PHYTOREMEDIATION TREATMENT
LABANGAN
SAN ROQUE
PANDURUCAN RIVER
Legend
RiverPoints
Sampling Site
San Jose
Occidental Mindoro
Total Suspended Solid
BARANGAY 4
BARANGAY 5
0 0.175 0.35 0.7 Km
AFTER THE PHYTOREMEDIATION TREATMENT
Sampling Points
Total Suspended Solids
0 1.75 3.5 7 Km
OCCIDENTAL MINDORO
LABANGAN
SAN ROQUE
BARANGAY 4
BARANGAY 5

(e)


BEFORE THE PHYTOREMEDIATION TREATMENT
LABANGAN
SAN ROQUE
PANDURUCAN RIVER
Legend
RiverPoints
Sampling Site
San Jose
Occidental Mindoro
Nitrate
0.1 - 0.111
0.112 - 0.122
0.123 - 0.133
0.134 - 0.144
0.145 - 0.155
0.156 - 0.166
0.167 - 0.177
0.178 - 0.188
0.189 - 0.199
0.2 - 0.21
BARANGAY 4
BARANGAY 5
0 0.175 0.35 0.7 Km
AFTER THE PHYTOREMEDIATION TREATMENT
Sampling Points
0.1
0 1.75 3.5 7 Km
OCCIDENTAL MINDORO
LABANGAN
SAN ROQUE
BARANGAY 4
BARANGAY 5

(f)

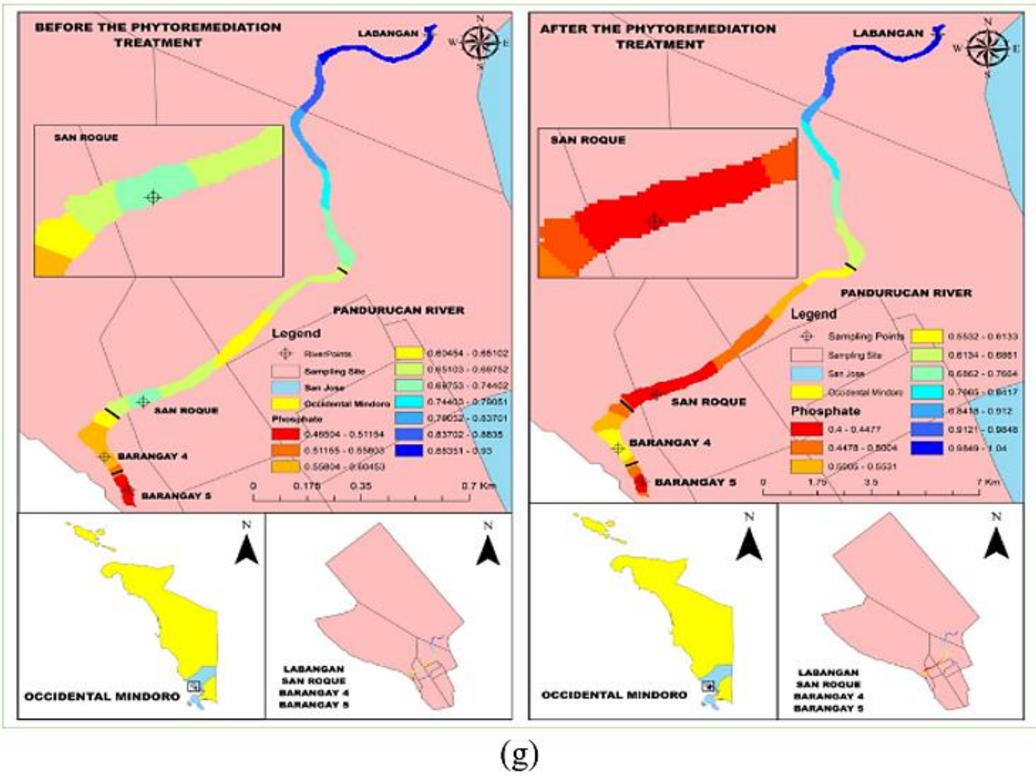


Fig. 4. Spatial maps of water quality parameters before and after the phytoremediation treatment: a) temperature; b) pH level; c) dissolved oxygen; d) chloride; e) total suspended solids; f) nitrate as NO_3-N; g) phosphate.

Figure 4 shows the generated map of water quality parameters before and after the installation of the phytoremediation treatment. The showed notable improvements in several key water quality parameters, particularly in San Roque, that was identified as the most polluted site before the application of the treatment pool. Before phytoremediation, the water temperature in Labangan and San Roque ranges from 29.86°C to 30.29°C with Brgy. IV has slightly lower values. After the installation of the water treatment pool, San Roque experienced a decrease in temperature, ranging from 29.02°C to 29.40°C. The pH levels before treatment varied, with Brgy. IV and Brgy. V becoming more alkaline, while San Roque had lower pH values between 7.49–7.94. After phytoremediation, pH levels in San Roque stabilized between 7.4 to 7.785. The DO levels improved significantly, particularly in San Roque, where values were critically low before the treatment. After the intervention, DO levels increased to 4.31 mg/L to 5.37 mg/L. The nitrate concentrations also showed a positive trend, decreasing from 0.1440–0.1879 mg/L in San Roque to 0.1 mg/L. The phytoremediation system effectively reduced TSS in San Roque, lowering levels from 17.0015–19.0007 mg/L to 12.801–14.1004 mg/L, and decreased phosphate concentrations, with values dropping from 0.69753–0.74402 mg/L to 0.4–0.464 mg/L. The chloride levels increased along the river, with the lowest values in Labangan and the highest in Brgy. V, but after phytoremediation, chloride concentrations in San Roque rose significantly to 14,528.02–17,209.84 mg/L.

Water Quality Prediction Model

The water quality data collected after the installation of a phytoremediation treatment pool in the Pandurucan River was utilized to develop a predictive model. The researchers forecasted water quality parameter values for the next five (5) years using the scatter linear regression. The Analytical Hierarchy Process (AHP) was applied to systematically prioritize various water quality parameters based on the relative significance to enhance the reliability of the predictions. The DO was identified as the most significant water quality parameter by the experts from the sanitary office, barangay health office, and Prime Water management, followed by the nitrate, TSS, chloride, pH level, phosphate, and temperature. The integration of spatial analysis and statistical modeling provided a comprehensive framework for evaluating the long-term impacts of phytoremediation.

Figure 5 shows the generated map of the Pandurucan River's water quality after the implementation of phytoremediation treatment in Brgy. San Roque and the projected future conditions of the river. The water quality after the phytoremediation treatment in San Roque demonstrated a noticeable improvement. The presence of green and yellow zones in the treated section indicated a reduction in pollutant levels. However, in the downstream areas, particularly Barangay IV and Barangay V, still exhibited poor water quality. The predicted water quality model projected future trends of water quality. The upstream section near Labangan is expected to maintain relatively good conditions, while the water quality in San Roque is projected to improve due to the phytoremediation water treatment. However, the midstream and downstream areas, particularly Barangay 4 and Barangay 5, remain in poor condition.

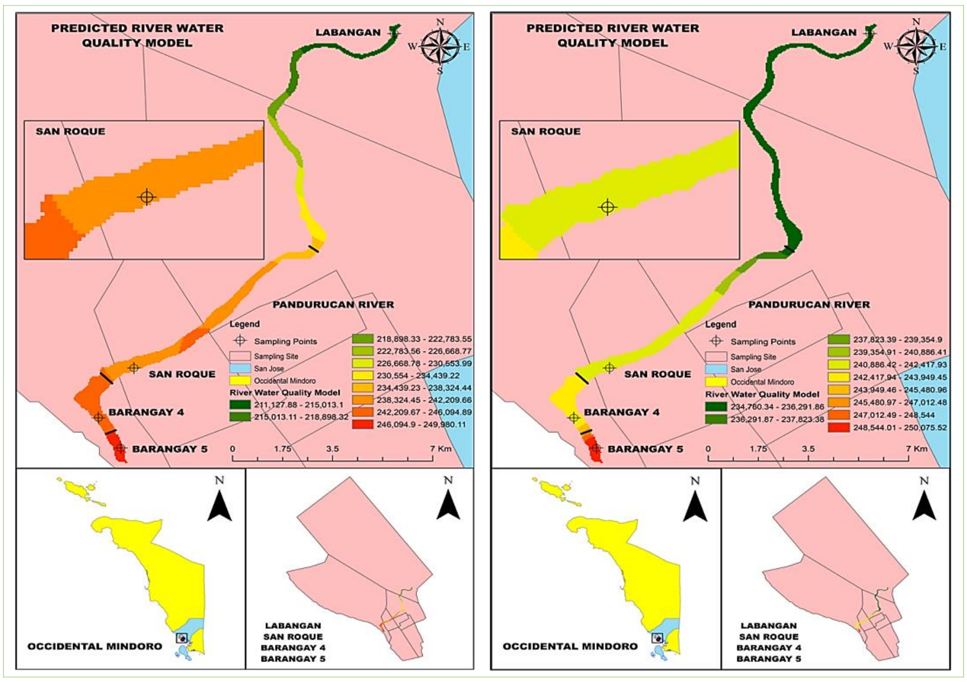


Fig. 5. Water Quality Prediction map of Pandurucan River.

DISCUSSION

The study revealed the present condition of the Pandurucan River. Water temperature exceeded the allowable range at some stations, particularly in San Roque, where reduced river flow contributed to heat retention (Booker & Whitehead, 2021). The DO levels were generally low, especially in San Roque and Labangan, likely due to limited water flow and anthropogenic pollution (Naubi et al., 2016). High chloride concentrations were recorded in Brgy. V due to saltwater intrusion, which may disrupt freshwater ecosystems. Additionally, elevated phosphate levels in Brgy. Labangan and Brgy. San Roque were linked to agricultural runoff and sewage discharge, reinforcing studies by Mekonnen, M. M., & Hoekstra, A. Y. (2017) on phosphorus pollution in freshwater systems. The computed WQI values for the four sampling stations indicated that all the water samples failed to meet the allowable standards set by the DENR for water quality. The WQI results reflect that all sampling stations exhibit poor water quality, which is consistently threatened and compromised by surrounding environmental factors. Brgy. San Roque recorded the lowest WQI, marking it as the station with the poorest water quality. After installing the water treatment pool in San Roque, water quality parameters improved temperature, pH, TSS, nitrate, and phosphate levels, while chloride remained high. After the statistical analysis of the result, the efficacy of the phytoremediation treatment showed significant improvements, particularly in DO, pH, and temperature, with p-values less than 0.05. However, an increase in chloride levels was observed, which was associated with factors such as wastewater discharge and saltwater intrusion. The improvements in TSS, nitrate, and phosphate concentrations highlighted the effectiveness of aquatic plants in enhancing water quality (Ansari et al., 2020). The phytoremediation treatment in Brgy. San Roque improved water quality, with reduced pollutants in the treated area; however, Brgy. IV and V remain polluted, highlighting the need for further interventions. Future projections show continued improvement in San Roque, but other areas require additional treatments. Moreover, the predicted model was validated using the coefficient of determination. The result revealed that 82% of the variability in water quality shows a strong correlation between the observed and predicted values, which makes the model an excellent tool for forecasting and directing environmental management. The researchers presented the study to the Municipal Environment and Natural Resources Office (MENRO) to increase its reliability. The MENRO recognized the importance of the study in offering crucial information about how phytoremediation works as an economical and environmentally friendly way to enhance water quality. Furthermore, predictive models could be a tool for future environmental decision-making that requires additional interventions and optimizing remediation efforts. The municipality's environmental management plans could benefit significantly from the study to protect aquatic life, improve the water quality, and ensure long-term sustainability.

CONCLUSION

The assessment of the Pandurucan River's water quality showed temperature fluctuations, low dissolved oxygen, high chloride and phosphate levels, and signs of pollution. While the pH, nitrate, and TSS levels remained within acceptable standards, saltwater intrusion and nutrient pollution suggest significant environmental stress. Moreover, all four stations' Water Quality Index (WQI) failed to meet the DENR standards, indicating poor water quality.

Among these four sampling stations, Brgy. San Roque has the lowest WQI, thus highlighting the significant pollution in the area. However, the Solar-Powered Phytoremediation Water Treatment Pool improved key water quality parameters, enhanced dissolved oxygen, pH, and temperature, and reduced TSS, nitrate, phosphate, and chloride levels.

Additionally, the ArcGIS-based water quality model effectively visualized spatial variations, demonstrating significant improvements in all water quality parameters in Brgy. San Roque after phytoremediation. Furthermore, phytoremediation in Brgy. San Roque significantly reduced pollutants, improving water quality in the treated section. However, downstream areas remain polluted, indicating the need for further intervention. The predictive model suggests continued improvements in San Roque and stable conditions in Labangan, but pollution in downstream areas persists. Therefore, expanding treatment efforts is essential for comprehensive river restoration. Lastly, the prediction model accurately captures water quality variations, proving to be a reliable tool for forecasting and environmental management.

To enhance water quality monitoring and management in the Pandurucan River, it is recommended to increase sampling stations for better spatial variability capture and extend monitoring across seasons to understand annual changes. Utilizing remote sensing and GIS modeling can identify pollution-affected areas while expanding assessments to include heavy metals and emerging pollutants will provide a comprehensive view of the river's health. Additionally, implementing multi-tiered treatment systems with salt-tolerant plants can improve phytoremediation, and treatment designs should focus on durability and scalability. Conducting a multifactorial analysis of land use, industrial activities, and meteorological patterns will help pinpoint pollution sources supported by statistical methods to identify significant contributors to water quality degradation. Lastly, analyzing river flow patterns is essential for optimizing treatment efficiency, collectively contributing to the sustainable management of the Pandurucan River.

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