

POTENTIAL OF MANGROVE PALM (*Nypa fruticans* T.) BIOCHAR FOR LEAD ADSORPTION IN SEAWATER SAMPLE FROM OROQUIETA CITY

A RESEARCH PAPER

Presented to
the Faculty of Bachelor of Science in Medical Technology,
Misamis University
Ozamiz City



In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science in Medical Technology

**ALONAH JHARY M. CARLOS
DOROTHY M. ESPANILLO
RHYNE GWENN J. GALGO
JANANE MELODY B. GARCIA
KATHLEEN FAYE C. PABRIGA
JEMEL FRITZ D. VILLANTEZ**

June 2026



Misamis University
Ozamiz City
COLLEGE OF MEDICAL TECHNOLOGY



DEPARTMENT OF MEDICAL TECHNOLOGY

CERTIFICATE OF PANEL APPROVAL

The research paper attached here to, entitled **"POTENTIAL OF MANGROVE PALM (*Nypa fruticans* T.) BIOCHAR FOR LEAD ADSORPTION IN SEAWATER SAMPLE FROM OROQUIETA CITY"**, prepared and submitted by **ALONAH JHARY M. CARLOS, DOROTHY M. ESPANILLO, RHYNE GWENN J. GALGO, JANANE MELODY B. GARCIA, KATHLEEN FAYE C. PABRIGA, and JEMEL FRITZ D. VILLANTEZ**, in partial fulfillment of the requirements for the degree **BACHELOR OF SCIENCE IN MEDICAL TECHNOLOGY**, is hereby recommended for approval.

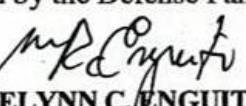

DARWIN R. TALARAN, LPT

Adviser

8/4/2020

Date

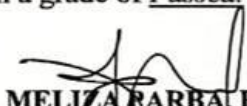
Approved by the Defense Panel Committee with a grade of Passed.


MARIE ROSELYNN C. ENGUITO, MSc. Bio

Member

8/4/2020

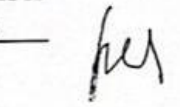
Date


MELIZA FARBA, PhD

Member

8/4/2020

Date

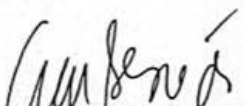

KARL MAXEL O. LAO, RMT, MSc. MLS

Chairman

8/5/2020

Date

This research paper is approved in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN MEDICAL TECHNOLOGY**.


EVANGELINE M. SENEDO, RMT, MATMRS

Dean, College of Medical Technology

8/5/2020

Date

ABSTRACT

Heavy metal pollution of water by lead (Pb) is a severe environmental and health issue. This research aimed to identify the effectiveness of *N. fruticans* (nipa palm) biochar as a low-cost, eco-friendly, and alternative adsorbent for the removal of lead from contaminated water systems. The biochar was generated by pyrolysis of dried *N. fruticans* biomass and used on polluted water with known concentrations of Pb. F.A.S.T. Laboratory analysis utilized electrothermal atomic absorption spectrometry (ETAAS) to analyze heavy metal concentration prior and after treatment. The findings indicated that *N. fruticans* biochar efficiently decreases the concentrations of Pb, which signified its possibility as a sustainable water purification and environmental remediation solution with the use of locally sourced materials.

Keywords: *adsorption, biochar, chromium, lead, N. fruticans, seawater, water purification*

DEDICATION

This research paper is dedicated wholeheartedly to:

To Almighty and Heavenly Creator, the one and only God, whose guidance, strength, and quiet presence carried us throughout every stage of this study. We acknowledge that without His wisdom and providence, the completion of this research would not have been possible.

To our family, whose sacrifices often went unnoticed but were deeply felt throughout this journey. Their patience, understanding, and belief in our abilities gave us the motivation to continue even in moments of uncertainty in our academic pursuits.

To our friends, whose companionship provided a sense of balance through shared laughter and companionship that made the process less heavy and more bearable.

To our instructors who extended their hands in helping us; to our adviser whose guidance went beyond instruction; and to all the people who believed in us.

This study reaches its completion not by individual strength but through the steady support and belief extended to us along the way. For all of this, we are truly grateful.

Thank you!

Jhary, Dorothy, Rhyne, Janane, Kathleen, and Jemel

ACKNOWLEDGEMENT

The researchers would like to express their deepest and most sincere gratitude to all the individuals who contributed to the completion of this research study.

First and foremost, we humbly offer our utmost thanks to Almighty God for His constant guidance, strength, and countless blessings throughout the entire research process. Without His grace, this study would not have been feasible.

We want to extend our heartfelt appreciation to our research adviser, **Mr. Darwin Taylaran**, for his invaluable guidance, knowledge, and continuous support. His expertise and encouragement greatly helped us in developing this study and in writing this research.

Our sincere thanks are also given to **Ma'am Nelfa D. Canini** for her patience, constructive feedback, and assistance in reviewing our manuscript. Her insights significantly improved the quality of this research.

We would also like to express our gratitude to the panelists, Mr, **Karl Maxel O. Lao, RMT, MSc. MLS**, Ma'am **Marie Rosellyn C. Enguito, MSc. Bio**, and Ma'am **Meliza Parba, PhD**, for their valuable suggestions, expertise, and constructive criticisms, which significantly enhanced and improved the quality of this research and its revisions. Their insights played a crucial role in refining this study.

We are also grateful to the kind individual who assisted us in collecting seawater samples despite the strong waves; we truly appreciate his effort and courage.

willingness to help and dedication ensured the success of our data collection process.

Special thanks are extended to **Kathleen's mother** for generously taking the time to drive us to Cagayan de Oro City to deliver our water samples to F.A.S.T. Laboratory. Her support and willingness to help us meet our research requirements played a vital role in the completion of this study.

Furthermore, we would like to extend our deepest gratitude to our families for their endless support, motivation, encouragement, and inspiration. Their unwavering belief in us gave us the strength to overcome the challenges encountered during the conduct of this study. Their sacrifices, understanding, and constant reassurance have been a guiding force in overcoming these challenges.

Lastly, we extend our gratitude to everyone who, in one way or another, contributed to the success of this study. Your support and assistance are deeply appreciated and remembered by the researchers. **Dorothy, Alonah, Rhyne, Janane, Kathleen, & Jemel.**

All glory and honor are given to God.

TABLE OF CONTENTS

	Page
TITLE PAGE	i
APPROVAL SHEET	ii
ABSTRACT	iii
DEDICATION	iv
ACKNOWLEDGEMENT	vi
TABLE OF CONTENTS	vii
LIST OF FIGURES	viii
LIST OF TABLES	ix
LIST OF APPENDICES	x
INTRODUCTION	
Introduction	1
Objectives of the Study	5
Significance of the Study	5
Scope and Delimitation	6
MATERIALS AND METHODS	
Research Design	8
Research Setting	8
Research Material	9
Preparation of Biochar	11
Collection and Preparation	12
Experimental Procedure	12
DATA ANALYSIS	14
RESULTS AND DISCUSSIONS	15
CONCLUSION AND RECOMMENDATIONS	21
LITERATURE CITED	25
APPENDICES	23
CURRICULUM VITAE	45

LIST OF FIGURES

Figure No.	Title	Page
Figure 1.	Conceptual Framework	4
Figure 2.	Map showing the location of the water sampling site.....	9
Figure 3.	<i>N. fruticans</i> sample.....	10
Figure 4.	Map showing the location of <i>N. fruticans</i> collected.....	10
Figure 5.	Procedure for obtaining charcoal from <i>N. fruticans</i>	12
Figure 6.	Procedure for treating the water sample	14

LIST OF TABLES

Table No.	Title	Page
Table 1.	Lead (Pb) concentration in Seawater Samples before and after.....	15
Table 2.	Adsorption Capacity and Removal Efficiency of <i>N. fruticans</i>	17
Table 3.	Comparison of Lead concentration with DENR Administration.....	19

LIST OF APPENDICES

Appendix	Title	Page
Appendix A.	Approval Letter of Consent.....	27
Appendix B.	Participant's Letter of Consent.....	33
Appendix C.	Raw Data and Computation.....	39
Appendix D.	Documentation.....	44
Appendix E.	Turnitin Results.....	50
Appendix F.	Grammarly Results.....	51

INTRODUCTION

Background of the Study

Nipa palm (*N. fruticans*), which belongs to the Arecaceae family, is a recurring mangrove palm and is widely distributed throughout the tropical and subtropical regions of Southeast Asia, including the Philippines (Mantiquilla et.al., 2022). It is a non-wood plant that contains a high amount of lignocellulosic material, which makes it a suitable charcoal precursor, and recent compositional analysis found that nipa can produce biochar effectively. Because of these characteristics, carbonized nipa biomass is considered a suitable adsorbent candidate, as lignocellulosic materials can be transformed into carbon-rich solids with effective adsorption capabilities (Haryanti et.al., 2024). Studies involving the Arecaceae family, particularly the nipa palm (*N. fruticans*) nut, have demonstrated its potential as an adsorbent for lead removal (Hoang et al., 2022).

Adsorption is a surface phenomenon wherein atoms, ions, or molecules accumulate on the surface of another material through binding. It is a simple, economical technique that can produce an effective adsorbent for heavy metals from industrial discharge (Natrayan et al., 2022). Charcoal and activated carbon are widely recognized as effective adsorbents because of their porous structure and large surface area. Due to its high adsorption efficiency and low production cost, biochar has emerged as a promising material for the removal of heavy metals from contaminated water (Bayar et al., 2024). On the other hand, the presence of lead in water systems poses a significant threat to both environmental quality and public health due to its toxicity and relentless presence from human-related

activities. Because it is non-biodegradable, it can accumulate in aquatic environments and enter the food chain, increasing the risk of long-term exposure in humans and other organisms. Chronic exposure to this heavy metal has been associated with serious health effects. As industrialization and other human activities continue to introduce lead into the bodies of water, the effective removal of this heavy metal from contaminated water has become increasingly important.

Conventional water treatment technologies like ion exchange, membrane filtration, and chemical precipitation are reliable but usually costly and energy-demanding, hence less suitable at the community level (Qasem et al., 2021). This has driven the creation of low-cost, sustainable, and environmentally friendly alternatives, including biochar, a carbon-rich product made from the pyrolysis of biomass. Pyrolysis transforms biomass into biochar, which can be processed and become activated carbon. Although activated carbon was not used in this study due to financial constraints, research by Wijana et al. (2021) supports the claim that using chemicals as an activator to convert biochar into activated carbon did not significantly alter its characteristics. Some uses of biochar involve water purification and its use as a briquette for alternative fuel (Wijana et al., 2021). Additionally, biochar has the potential to function as a soil amendment and carbon sequestration agent, helping to reduce greenhouse gas emissions by storing carbon that would be released as carbon dioxide during biomass decomposition (Mosa et al., 2023).

Research has indicated that biochar contains a porous structure, high surface area, and functional groups that allow for strong adsorption of metal ions (Kumkum et al., 2024). Several studies have proven biochar's capability for heavy metal removal. For instance, Mohadi et al. (2021) have proven that rice husk biochar can efficiently adsorb chromium.

from wastewater, while Chen et al. (2021) reported that coconut shell biochar exhibited great manganese adsorption capacity.

In the Philippines, Abbas et al. (2022) researched bamboo-based biochar and reported that it can be used for water treatment in the presence of lead. However, studies on nipa palm waste conversion to biochar are limited. There is also a lack of locally generated data assessing the performance of *N. fruticans* biochar using contaminated water samples from coastal areas in Misamis Occidental. Addressing this is important to determine whether this abundant local biomass can serve as an effective, low-cost, and sustainable adsorbent for community-based water treatment.

N. fruticans is found to be abundant in the coastal regions of Tudela, Misamis Occidental, and possesses high lignocellulosic composition, which is said to produce more carbon yield and adsorption efficiency (Haryanti et.al., 2024). The use of nipa palm waste for producing biochar has the potential to reduce biomass waste, provide livelihood support at the local level, and end environmental pollution in the surrounding community.

In addition, research from the Asian Journal of Biological and Life Sciences (2022) reported elevated levels of heavy metals in mangrove-related water systems in the Philippines, emphasizing the need for locally adapted, low-cost water treatment media. Hence, this research seeks to investigate the viability of *N. fruticans* biochar as a promising adsorbent for the elimination of lead (Pb) from water systems. By assessing its adsorption capacity and comparing treated and untreated water samples, this study hopes to contribute to sustainable and community-based interventions for water pollution in Misamis Occidental.

Conceptual Framework

This study follows a sequential process illustrated through a flowchart.

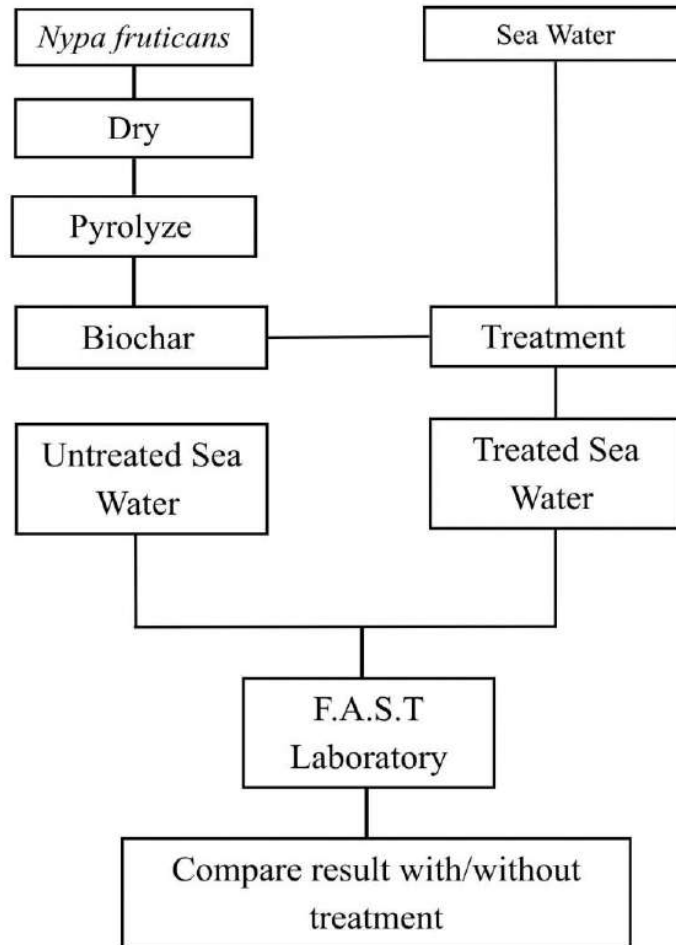


Figure 1. Conceptual Framework of the Study.

This diagram illustrates the use of *N. fruticans* as a source of biochar for seawater treatment. The plant material undergoes cleansing, drying, and pyrolysis to produce biochar. Seawater samples are then analyzed in the F.A.S.T Laboratory to determine the presence of heavy metals. The produced biochar is then applied as an adsorbent in water treatment, and the quality of seawater with and without biochar treatment is compared to evaluate its effectiveness in removing heavy metals.

Objectives of the Study

The general purpose of this research is to find out the potential of *N. fruticans* biochar as a good adsorbent in removing lead (lead) from seawater. Specifically, the study aimed to:

1. identify the presence and intensity of lead (Pb) in the collected seawater;
2. determine the adsorption capacity of *N. fruticans* biochar for removing lead from the seawater; and
3. compare the efficacy of *N. fruticans* biochar-treated seawater and untreated seawater to identify the efficiency of heavy metal removal.

Significance of the Study

The significance of this study is that it investigates the potential of *N. fruticans* biochar as a low-cost, locally sourced, and sustainable adsorbent for lead (Pb). By evaluating its adsorption efficiency, the study contributes to the growing body of knowledge on biomass-based adsorbents. It highlights the value of utilizing nipa palm fruit as a renewable resource. The findings may provide baseline information for the development of environmentally sustainable adsorption materials. It may also serve as a basis for pre-treatment of adsorbent coastal water treatment and desalination systems. For the people, this study demonstrates the potential of converting an abundant natural resource into an enhanced biochar with adsorption properties, encouraging the sustainable use of locally available biomass. For the local government, the findings may serve as a scientific

reference for promoting natural resource utilization, such as biomass, and for future environmental management initiatives involving locally sourced adsorbents. For future researchers, this study provides baseline data on the adsorption efficiency of *N. fruticans* biochar for lead, which may serve as a foundation for future investigations on its adsorption performance under different conditions and its application to other heavy metals or other water systems.

Scope and Delimitations

This study focused on determining the efficiency of *N. fruticans* biochar as an adsorbent for lead (Pb) from seawater. *N. fruticans* samples were collected from Tudela, Misamis Occidental, where nipa palms are abundant. The researchers prepared the biochar, while seawater was collected in Oroquieta City. The study included adsorption experiments and the analysis of heavy metal concentrations before and after treatment. Only lead was tested as a heavy metal, excluding other possible contaminants. Since the concentration of lead collected from the seawater is not considered a contaminant or pollutant, the study focused only on the potential of charcoal as an adsorbent for lead. Environmental factors such as temperature and contact time were controlled within the laboratory to maintain consistency.

Despite these limitations, the results of this research were expected to provide valuable baseline information about the potential of *N. fruticans* biochar as a low-cost and sustainable adsorbent for removing lead from seawater. These findings can serve as a reference for future studies that aim to improve biochar-based water treatment methods or explore other natural materials for heavy metal remediation.

MATERIALS AND METHODS

Research Design

An experimental study was conducted to evaluate the effectiveness of *N. fruticans* biochar in removing lead (Pb) from seawater samples collected from Oroquieta City. In this experiment, biochar produced from *N. fruticans* was applied to seawater samples, and lead concentrations were measured before and after treatment to determine adsorption efficiency. The study involved controlled laboratory conditions to ensure accurate measurement and comparison of heavy metal levels. By testing a locally available plant resource as a biochar source, the research aimed to determine whether *N. fruticans* can serve as a potential low-cost and sustainable material for heavy metal removal in seawater.

Research Setting

This study was conducted in the laboratory of Misamis University located in Ozamiz City. The laboratory was equipped with an autoclave, which was essential for thoroughly sterilizing the bottles used to collect seawater samples for heavy metal analysis. Seawater samples were collected from Oroquieta City, while samples of *N. fruticans* were gathered from areas where nipa palms are abundant in Tudela, Misamis Occidental.

The preparation of biochar and the adsorption experiments for the removal of lead (Pb) were carried out under controlled laboratory conditions, ensuring consistency and reliability of results.

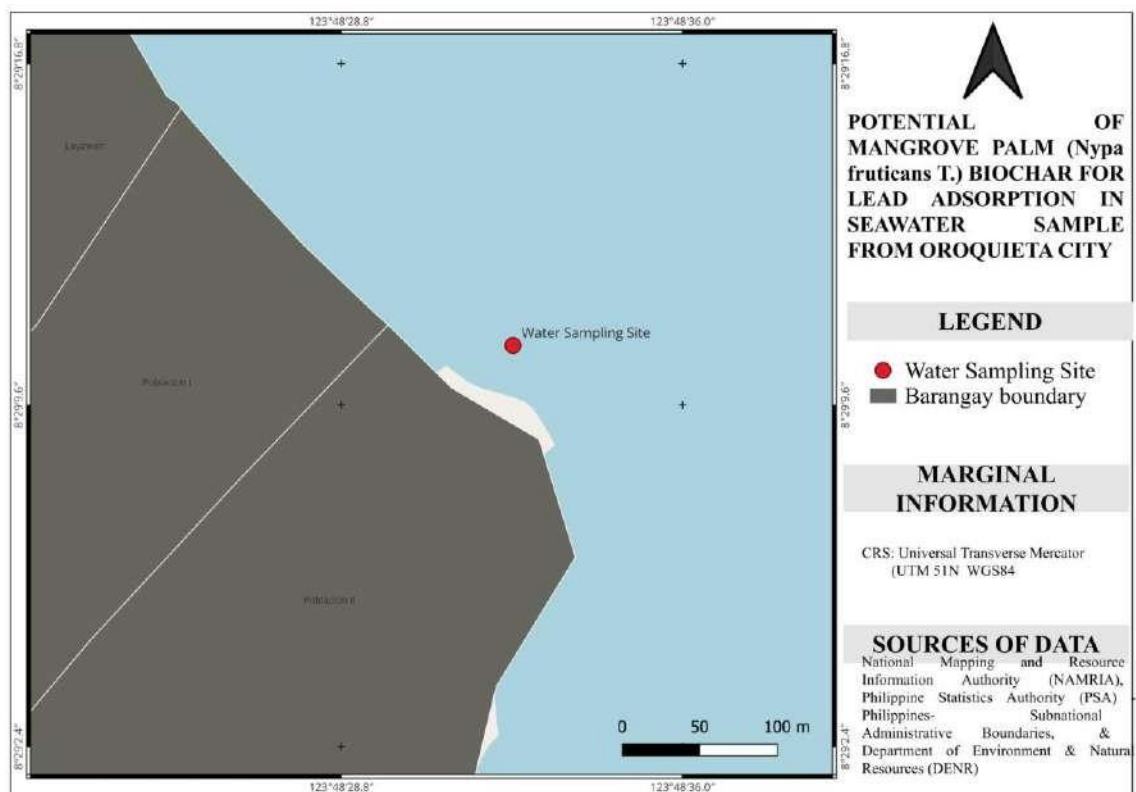


Figure 2. GIS mapping of the seawater sampling site in Oroquieta City.

Further analysis of the treated and untreated seawater samples was conducted at the F.A.S.T. Laboratories in Cagayan de Oro City to determine the concentrations of heavy metals present before and after treatment.

Proper laboratory safety procedures were strictly followed during the handling of seawater samples and biochar. Laboratory surfaces and materials were cleaned and disinfected before and after each experiment, and all chemical wastes and contaminated materials were disposed of according to standard laboratory safety and environmental guidelines to ensure safe and responsible research practices.

Research Material

The primary raw material used in this study was *N. fruticans*, commonly known as the nipa palm, which was collected from the mangrove areas of Tudela, Misamis Occidental. The nipa palm was selected because it is readily available in the area and contains a naturally high carbon content suitable for biochar production. Seawater samples were collected from selected areas in Oroquieta City, which were chosen due to the potential presence of lead (Pb) associated with nearby construction activities, docked vessels, and industrial facilities. These human-related activities were considered possible sources of lead input, making the area suitable for evaluating the adsorption efficiency of *N. fruticans* biochar.



Figure 3. *N. fruticans*

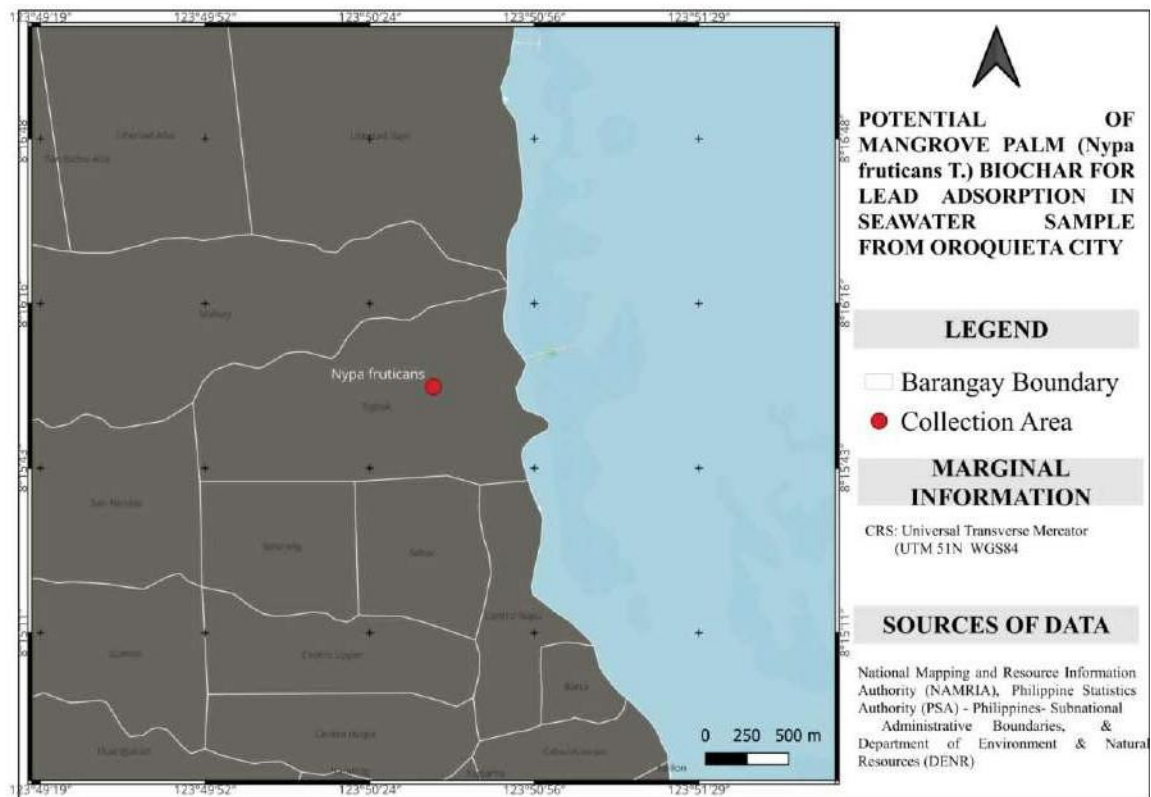


Figure 4. GIS mapping of the location where *N. fruticans* samples were collected in Tudela, Misamis Occidental, Philippines.

Other materials and equipment used in the study are filtration materials, a weighing scale for precise measurement, a mortar and pestle for grinding to produce powdered charcoal, and a canister for the production of biochar. Further analysis of heavy metal concentrations in the seawater samples was conducted at F.A.S.T. Laboratory using a 3113 B. Electrothermal Atomic Absorption Spectrophotometer (EAAS) to ensure accurate and reliable measurement of lead levels before and after treatment. EAAS, also known as Graphite Furnace Atomic Absorption Spectrophotometry (GFAAS), is an analytical technique used to determine trace amounts of metallic elements, such as lead, in liquid or solid samples, and is widely used because of its high sensitivity and ability to detect metals at very low concentrations (Bishop et.al., 2020).

Preparation of Biochar

The *N. fruticans* samples freshly obtained from Tudela were thoroughly sun-dried for approximately two days. The Nipa husk was chopped into small pieces, excluding the kernel; it was then sun-dried and subjected to pyrolysis in a charcoal canister for 6 hours under restricted oxygen (Minh et al., 2023). This converted the organic matter into carbon-rich biochar. The cooled biochar was powdered using a mortar and pestle to achieve a uniform particle size (Ahmed et al., 2025). The biochar was then kept in airtight containers to preserve its quality and avoid moisture uptake prior to application for adsorption experiments (Rafiq et al., 2023).



Figure 5. Procedure for obtaining charcoal from *N. fruticans*.

The diagram shows the procedure for producing charcoal from *N. fruticans*, starting from fruit collection, husk preparation, drying, pyrolysis, cooling, crushing, and powdering for further use in the study.

Collection and Preparation

Water samples were obtained from the sea at 97 Independence Street, Poblacion-1, Oroquieta City, with suspected lead presence due to local industrial effluent discharges and domestic waste. The water sample was obtained from a depth of two feet (2 ft) and had a volume of 4 liters, each kept in a long-neck bottle, which was autoclaved before sample collection and labeled right away based on where they were collected. As per the laboratory's instructions, the samples were kept in an ice-cold container and taken to F.A.S.T. Laboratory to undergo analysis to determine the concentration of lead. These actual seawater samples were subsequently utilized directly in the experiment to determine the adsorption capacity of *N. fruticans* biochar under real-world environmental conditions.

Experimental Procedure

Three grams of *N. fruticans* biochar were added to each 1-liter sample of the seawater (Vaghela et.al., 2023). The mixture was then left to soak for 4 hours to ensure optimal contact between the biochar and the heavy metal ions (Yang et.al., 2023). Following the reaction time, the mixture was filtered to remove the biochar from the treated water. The treated samples were also examined at the F.A.S.T. Laboratory to identify residual lead levels. Heavy metal concentration reduction was computed to assess the adsorption efficacy of the biochar. The results were compared with the control samples to determine how effectively the biochar removed lead.

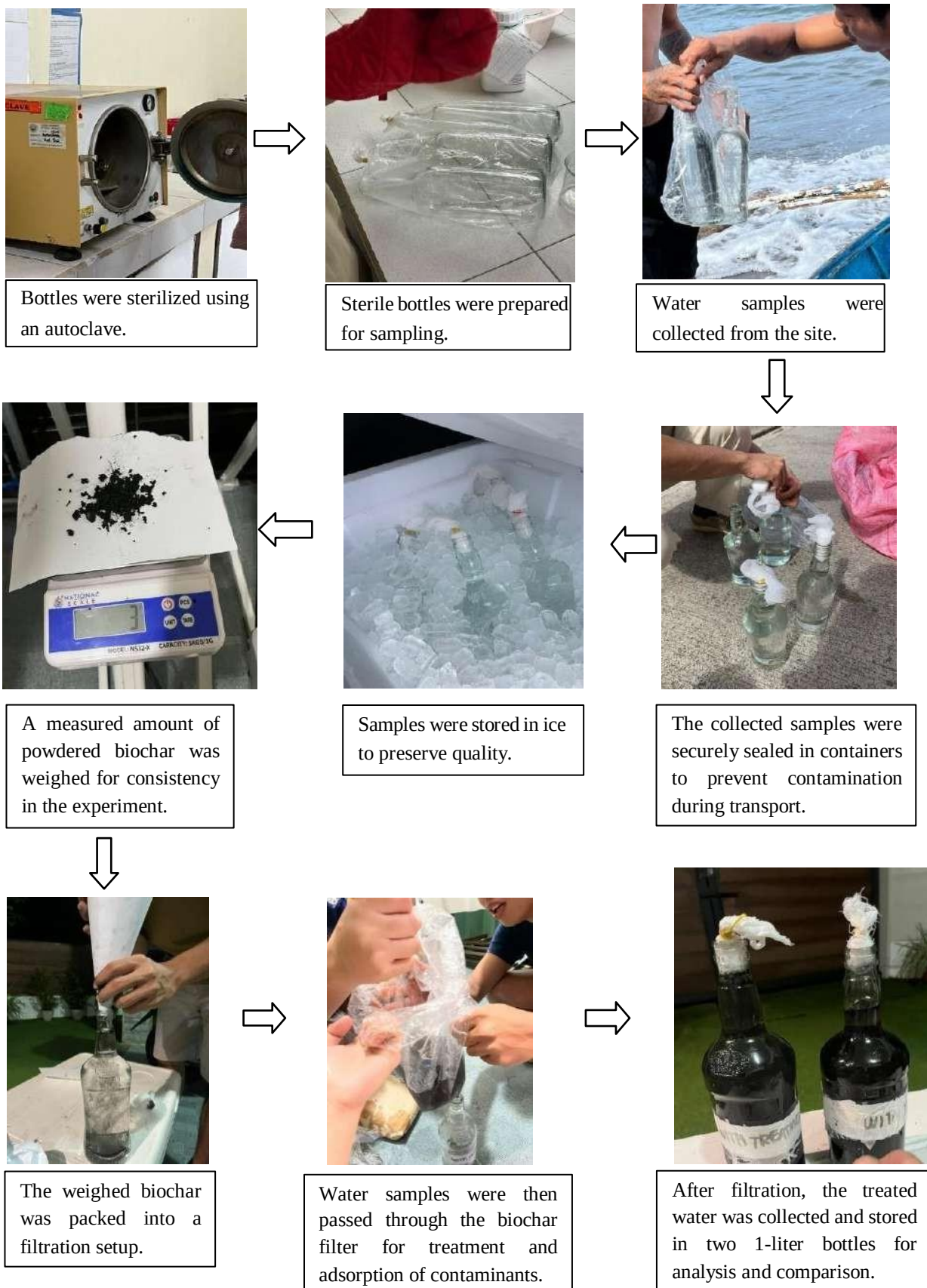


Figure 6. Procedure for treating the water sample using *N. fruticans* biochar.

The diagram shows the procedure for treating water samples using *N. fruticans* biochar, starting from bottle sterilization, water collection, sample preservation, biochar weighing, filtration, and collection of treated water for analysis.

Data Analysis

Samples collected include the initial and final concentrations of lead in seawater. The efficiency of the adsorption of *N. fruticans* biochar was calculated using the equation:

Adsorption Capacity (q)

$$q = \frac{(C_i - C_f)V}{m}$$

In percentage, the removal efficiency was calculated as in equation (2):

Removal Efficiency (%)

$$R = \frac{C_i - C_f}{C_i} \times 100$$

Where C_i is the initial concentration of the metal, C_f is the final concentration (mg/L), V is the volume of the water sample in Liters, and m is the mass of the biochar used in grams (Duwiejuah et.al., 2024).

RESULTS AND DISCUSSION

The study evaluated the effectiveness of *N. fruticans* biochar in removing heavy metals, specifically lead (Pb), from the collected seawater. Metal concentrations before and after treatment were analyzed, and adsorption capacity and removal efficiency were calculated.

Table 1 presents the lead (Pb) concentrations measured in two seawater samples before and after charcoal treatment. The untreated Seawater 1 recorded lead concentrations of 0.00854 mg/L, 0.00907 mg/L, and 0.00867 mg/L in the three replicate analyses, yielding a mean concentration of 0.00876 ± 0.00028 mg/L. The relatively small standard deviation indicates good analytical precision and consistency among the replicate measurements.

Table 1. Lead (Pb) Concentration in Seawater Samples Before and After Charcoal Treatment

Seawater Treatment	Treatment	Trial 1 (mg/L)	Trial 2 (mg/L)	Trial 3 (mg/L)	Mean $\pm$ SD
Seawater 1	Untreated (Control)	0.00854	0.00907	0.00867	0.00876 ± 0.00028
Seawater 2	Charcoal-treated	ND	ND	ND	ND
	Untreated (Control)	<0.005	<0.005	<0.005	<0.005

Note: ND = Not Detected (below the laboratory detection limit). Values for Seawater 1 are presented as mean $\pm$ standard deviation ($n = 3$). Seawater 2 results were reported by the laboratory as below the reporting limit (<0.005 mg/L) for all replicate analyses.

Following charcoal treatment, lead was not detected (ND) in all three replicate analyses of Seawater 1, indicating that the lead concentration was reduced to below the laboratory's analytical detection limit. This result demonstrates the capacity of charcoal to adsorb dissolved lead ions from seawater. Charcoal is recognized as an effective adsorbent because of its porous structure, high surface area, and abundance of active functional

groups that facilitate the adsorption of heavy metals through mechanisms such as physical adsorption, ion exchange, and surface complexation. It interacts with lead (Pb^{2+}) by binding the metal ions to its surface through functional groups such as hydroxyl and carboxyl, as well as through ion exchange and electrostatic attraction, allowing effective removal from water (Adelodun et.al., 2022). The absence of detectable lead after treatment therefore suggests that charcoal effectively removed the measurable lead present in the seawater sample.

In contrast, Seawater 2 exhibited lead concentrations of less than 0.005 mg/L in both untreated and charcoal-treated samples. Since all replicate analyses were already below the laboratory reporting limit before treatment, no measurable decrease in lead concentration could be observed after charcoal application. This finding indicates that Seawater 2 contained only trace levels of lead that were below the quantification capability of the analytical method. Consequently, although charcoal treatment maintained the low lead concentration, its adsorption efficiency could not be quantitatively evaluated for this sample.

The differences observed between the two seawater samples suggest that the effectiveness of charcoal treatment is influenced by the initial concentration of lead present in the water. A measurable reduction was observed only in Seawater 1 because detectable lead contamination existed before treatment, whereas Seawater 2 already exhibited lead concentrations below the laboratory reporting limit.

Table 2 presents the adsorption capacity of biochar derived from *N. fruticans* in removing lead from a polluted seawater across three trials. The data highlight the relationship between initial lead concentrations (*C_i*) and final concentrations (*C_f*), demonstrating the biochar's efficiency with a mean adsorption capacity of 0.00584 mg/g.

Table 2. Adsorption Capacity and Removal Efficiency of *N. fruticans* Biochar for Lead (Pb) Removal from Seawater

Parameter	Trial 1	Trial 2	Trial 3	Mean ± SD
Adsorption Capacity, <i>q</i> (mg/g)	0.00569	0.00605	0.00578	0.00584 ± 0.00019
Removal Efficiency (%)	100	100	100	100

Note: Adsorption capacity (*q*) and Removal Efficiency (%) were calculated using Equations (1) and (2). Values are presented as mean ± standard deviation (*n*=3). For the calculations, the final lead concentration (*C_f*) was assumed to be zero because the treated samples were reported as not detected.

In the first sampling, a total of 4 liters of seawater sample was collected, where every 2 liters was treated with 3g of biochar. Following treatment, lead was no longer detected. During the second sampling, the same volume of seawater and the same amount of charcoal were used; however, the initial lead concentration in the untreated water sample was already below the laboratory detection limit. Consequently, the initial concentration of lead could not be determined, making it impossible to calculate the adsorption capacity and removal efficiency for the second sampling. Therefore, only the data obtained from the first sampling were used to determine the adsorption capacity and removal efficiency of the biochar.

The concentration of lead (Pb) is variable depending on the time and

environmental parameters, which may lead to variation in concentrations depending on the date of the sampling (Li et al., 2025). Environmental factors such as tidal changes and freshwater inflow will play a part in affecting how heavy metals disperse in seawater. The tides will change the conditions of the environment in the coastal and intertidal areas, which favor the movement, alteration, and redistribution of heavy metals between sediments and the water column (Geng et al., 2024). When there is a high tide, the flow of seawater will lead to the dilution of lead concentration, while at low tide, there could be more influence of terrestrial sources and their contamination (Zhang et al., 2024). Additionally, rainfall will affect the concentration of heavy metals since the increased amount of rainfall will bring about surface runoff and increase water volume and hence dilute contaminants (McKenzie et al., 2024). Thus, it is important to maintain uniform conditions for sample collection, including date, time, and tidal conditions.

In addition to this, the physical and chemical properties of seawater such as salinity, dissolved oxygen, and temperature greatly affect the behavior and distribution of dissolved heavy metals (Li et al., 2025). Since heavy metals like lead easily react with particulate materials in the form of suspended solids and dissolved organic matter, there will be adsorption, deposition, and changes in their concentrations in the dissolved state (Zhang et al., 2024).

Table 3 compares the measured lead concentrations with the water quality guideline established by the Department of Environment and Natural Resources (DENR) Administrative Order No. 2016-08 for Class SC coastal and marine waters. The guideline specifies a maximum allowable lead concentration of 0.05 mg/L to protect aquatic life and maintain the designated beneficial uses of coastal waters.

Table 3. Comparison of Lead (Pb) Concentrations with the DENR Administrative Order No. 2016-08 Water Quality Guideline for Class SC Coastal and Marine Waters

Seawater Treatment	Treatment	Mean Lead Concentration (mg/L)	DENR Class SC Guideline Value (mg/L)	Compliance
Seawater 1	Untreated (Control)	0.00876 ± 0.00028	0.05	Complies
	Charcoal-treated	ND	0.05	Complies
	Untreated (Control)	<0.005	0.05	Complies
Seawater 2	Charcoal-treated	<0.005	0.05	Complies

Note: ND = Not Detected (below the laboratory detection limit). The DENR Administrative Order No. 2016-08 specifies a guideline value of 0.05 mg/L for lead (Pb) in Class SC coastal and marine waters.

The untreated Seawater 1 had a mean lead concentration of 0.00876 ± 0.00028 mg/L, which is substantially lower than the DENR guideline value of 0.05 mg/L. Therefore, although lead was detected in the sample, its concentration remained within the acceptable limit for Class SC waters. After charcoal treatment, lead was no longer detected in any of the replicate analyses, indicating that the treatment further reduced the concentration to below the laboratory detection limit. While treatment was not necessary to achieve regulatory compliance, the reduction demonstrates the adsorption efficiency of charcoal in minimizing trace concentrations of lead in seawater.

Similarly, Seawater 2 exhibited lead concentrations of less than 0.005 mg/L before and after treatment, remaining well below the DENR guideline value throughout the study. Because the initial lead concentration was already below the laboratory reporting limit, no measurable improvement could be demonstrated after charcoal treatment. Nevertheless, the results confirm that the seawater consistently complied with the national water quality standard.

Overall, both seawater samples met the DENR guideline for lead prior to treatment. However, charcoal treatment successfully reduced the detectable lead concentration in Seawater 1 to below the laboratory detection limit, highlighting its effectiveness as a low-cost adsorbent for reducing trace heavy metal contamination in seawater. Although the treatment did not alter the compliance status of either sample, the observed reduction in detectable lead suggests that charcoal may provide an additional safeguard against fluctuations in lead concentrations in coastal environments.

On the other hand, Rafiq et al. (2023) emphasized a limitation in recent biosorption research that must be addressed for laboratory findings to be applied to broader environmental management. As seawater contains a variety of cations and anions, their presence may negatively influence the adsorption-desorption of toxic metal ions to the surface of the adsorbent. The competitive nature of cations and anions reduces the removal efficiency of the targeted pollutant. Therefore, understanding changes in water salinity and their effect on the removal efficiencies of Pb and Cd remains crucial for assessing different biochars.

The findings of this study support the use of charcoal as a practical and sustainable adsorbent for the removal of dissolved lead from seawater. Its ability to reduce measurable lead concentrations to below the analytical detection limit demonstrates its potential application in coastal water remediation and environmental management. Future studies should evaluate different types of charcoal, adsorption contact times, particle sizes, and initial metal concentrations to optimize treatment efficiency and assess the applicability of charcoal under varying environmental conditions.

CONCLUSION AND RECOMMENDATION

According to the findings, nipa biochar effectively adsorbed lead from a seawater sample with initially detectable levels of lead. After treatment with *N. fruticans* biochar, lead was no longer detected in the treated water sample. This shows that biochar has the potential to adsorb lead from seawater under the conditions of the study.

Overall, the findings showed that *N. fruticans* biochar has the potential to be a low-cost and natural adsorbent for lead removal. The treated water showed improvement compared with untreated water, which supports the possible use of nipa palm biochar in water treatment. Therefore, this study may serve as a basis for future research on using locally available plant materials for removing heavy metals from contaminated water.

Future studies are recommended to supplement the seawater sample with lead, for which the concentration of the heavy metal is predetermined, to investigate the adsorption capacity of the biochar further. It is also advisable to test additional metals commonly found in polluted waters, such as cadmium, copper, nickel, zinc, and mercury, to determine the broader application of the biochar as an adsorbent. The amount of biochar used during treatment may also be increased to determine whether a greater amount of adsorbent can improve heavy metal adsorption. A higher amount of biochar may provide more surface area and more active sites where metal ions can attach, which can help improve adsorption. This would also help identify the most effective amount of biochar needed for treating lead in water.

Furthermore, future researchers may coordinate with relevant environmental agencies or consult available water quality monitoring data to identify the heavy metal with the highest recorded concentration in Oroquieta City waters. Determining the most prevalent contaminant in the area would allow future experiments to focus on locally significant pollutants and improve the practical importance of the study for environmental rehabilitation in Oroquieta City. This may also help researchers choose better sampling sites and collect water samples that truly represent the condition of the area. By using updated local data, future studies can produce findings that are more accurate, useful, and applicable to community-based water treatment programs. These efforts may also support local plans for pollution control, water protection, and the possible use of low- cost natural adsorbents such as *N. fruticans* biochar.

DECLARATION OF THE USE OF AI TOOLS

The researchers would like to acknowledge the use of artificial intelligence (AI) tools in the preparation of this study. ChatGPT was used to help paraphrase sentences for better understanding of concepts from related literature, as well as organize ideas and generate concepts related to the study.

The following prompts were used:

“Paraphrase sentences from related literature to improve clarity and understanding.”

"Generate ideas for the application of Biochar in Seawater systems."

The researchers would also like to acknowledge the use of Anara AI for assisting with easy searching of specific related research topics. The following prompts were used.

“Identify relevant published studies that support the use of biochar as an adsorbent for lead removal.”

Furthermore, Grammarly was used during the final stage of writing to check grammar, spelling, clarity, and sentence structure. All suggestions and outputs were carefully reviewed by the researchers and used when appropriate to improve the flow, clarity, and accuracy of the manuscript. These tools were used only as additional support and as a guide in the writing process.

AI was used only as a language assistance tool to improve the clarity, grammar, and readability of selected text and to help identify relevant published literature. All research questions, study design, analysis, interpretation of findings, conclusions, and final decisions regarding the content were developed, evaluated, and approved by the researchers. The intellectual contribution and critical thinking reflected in this study are entirely those of the researchers.

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APPENDIX A

Approved letter of Consent



Misamis University

Ozamiz City



MISAMIS UNIVERSITY RESEARCH CENTER

CERTIFIED: ISO 21001: 2018 Educational Organizations Management System by DNV
ACCREDITED: Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA)

MU-RC-042/13 November 2024

Thesis/Research Data Gathering Approval Form

Date: 01/28/26

Name of Authors: Cardo, Almah Jhary M., Garcia, Janine Melody B., Rariga, Kataroon Faye C., Villantez, Jemel
College/Department: College of Medical Technology
Research Title: Potential of Mangrove Palm (*Nypa fruticans* L.) Biochar for Heavy Metals Adsorption in Polluted Water System

Data Gathering Procedure:

a. Type of Research: (Kindly check)

- | | | |
|--|---|--|
| ☐ Quantitative | ☐ Qualitative | ☒ Experimental |
| ☒ Approved Research Title & Problem/Objectives | ☒ Approved Data Gathering Procedure | ☒ Approved Data Gathering Instrument/Data Sheets |

b. Respondents/Participants/Subject/Samples to be Collected:

c. Procedure:

- | | | | |
|---------------------------------|------------------------------------|--|--|
| ☐ Survey | ☐ Interview | ☐ Experimentation | ☒ Laboratory Testing |
|---------------------------------|------------------------------------|--|--|

d. Place of Implementation/Study Area: F.A.S.T Laboratory

If to be conducted outside the school campus, indicate the nature of transportation to be used:

- | | | | |
|---|---|---------------------------------|--|
| ☒ Own private vehicle | ☐ public utility vehicle | ☐ rental | ☐ Others, please indicate _____ |
|---|---|---------------------------------|--|

e. Date/s of Implementation/Sampling:

Attachments:

- | |
|--|
| ☐ Approved Letter of Consent from the designated authority in the area/place where the study is to be conducted |
| ☒ Signed Parents' Consent |

The thesis proposal mentioned above is hereby recommended for the commencement of data gathering implementation.

Recommended by:

DARWIN R. TAFARAN, LPT
Thesis/Research Adviser

NELFA B. CANINI, PhD
Thesis/Research Instructor

Approved by:

EVANGELINE M. FERRO, RMT, MATMRC
College Dean

APPENDIX A Cont'd



Misamis University

Ozamiz City



MISAMIS UNIVERSITY RESEARCH CENTER

CERTIFIED: ISO 21001: 2018 Educational Organizations Management System by DNV

ACCREDITED: Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA)

MU-RC-042/13 November 2024

Thesis/Research Data Gathering Approval Form

Date: 01/02/20

Name of Authors: Carlo Alonzo Thery M. Garcia, Janane Melody B. Rabiga, Kathleen Taye C. Villante, Jemel

College/Department: College of Medical Technology

Research Title: Potential of Mangrove Palm (Nyra fruticans L.) Biochar for Heavy Metal Adsorption in Polluted Water System

Data Gathering Procedure:

a. Type of Research: (Kindly check)

☐

Quantitative

☐

Qualitative

☒

Experimental

☒

Approved Research Title
& Problem/Objectives

☒

Approved Data
Gathering Procedure

☒

Approved Data Gathering
Instrument/Data Sheets

b. Respondents/Participants/Subject/Samples to be Collected: Mangrove Palm (Nyra fruticans L.)

c. Procedure:

☐

Survey

☐

Interview

☒

Experimentation

☐

Laboratory Testing

d. Place of Implementation/Study Area: Natural Science Laboratory, Misamis University

If to be conducted outside the school campus, indicate the nature of transportation to be used:

☐

Own private vehicle

☐

public utility vehicle

☐

rental

☐

Others, please
indicate

e. Date/s of Implementation/Sampling: _____

Attachments:

☐

Approved Letter of Consent from the designated authority in the area/place where the study is to be conducted

☒

Signed Parents' Consent

The thesis proposal mentioned above is hereby recommended for the commencement of data gathering implementation:

Recommended by:

DARWIN R. TAYLARAN, LIT
Thesis/Research Adviser

NELFA D. CANINI, PhD
Thesis/Research Instructor

Approved by:

EVANGELINE M. REYES, RMT, MATHEC
College Dean

APPENDIX A Cont'd



Misamis University

Ozamiz City

COLLEGE OF MEDICAL TECHNOLOGY



CERTIFIED: ISO 21001: 2018 Educational Organizations Management System by DNV
ACCREDITED: Philippine Association of Colleges and Universities Commission on Accreditation
(PACUCOA)

EVANGELINE M. SEÑEDO, RMT, MATMRS

Dean, College of Medical Technology

Misamis University

Dear Ms. Señedo,

Warm Greetings!

We are the 3rd year BS in Medical Technology students are writing to respectfully request permission to travel to Cagayan De Oro City to submit our sample for testing at F.A.S.T Laboratory. This testing is an essential part of our research entitled "**Potential of Mangrove Palm (*Nypa fruticans* T.) Biochar for Heavy Metals Adsorption in Polluted Water System**", which aims to evaluate the effectiveness of mangrove palm biochar in removing heavy metals from polluted water systems.

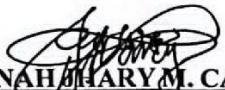
The proposed date of travel is February 13, 2026, and we assure you that all necessary safety protocols will be observed during the trip. We will take full responsibility for the logistics and expenses associated with this travel.

We kindly request your approval and support to allow us to carry out this critical step in our research. Your positive consideration of this request will greatly contribute to the success and timely completion of our study.

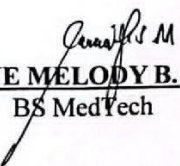
Thank you very much for your time and attention. We look forward to your favorable response.

APPENDIX A Cont'd

Respectfully,


ALONAH MARY M. CARLOS
BS MedTech

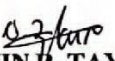

KATHLEEN FAYE C. PABRIGA
BS MedTech


JANANE MELODY B. GARCIA
BS MedTech

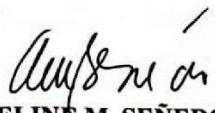

JEMEL FRITZ D. VILLANTEZ
BS MedTech

Noted by:


NELFA D. CANINI, PhD.
Research Instructor


DARWIN R. TAYLARAN, LPT
Research Adviser

Approved by:


EVANGELINE M. SEÑEDO, RMT, MATMRS
Dean, College of Medical Technology

APPENDIX A Cont'd



Misamis University

Ozamiz City

COLLEGE OF MEDICAL TECHNOLOGY



CERTIFIED: ISO 21001: 2018 Educational Organizations Management System by DNV
ACCREDITED: Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA)

HAYDEE D. VILLANUEVA, PhD.

Dean, College of Arts and Sciences
Misamis University

Dear Dr. Villanueva,

Warm Greetings!

We are the 3rd year BS in Medical Technology students and currently working on our research study entitled **“Potential of Mangrove Palm (*Nypa fruticans* T.) Biochar for Heavy Metals Adsorption in Polluted Water System”**. This study aims to determine the potential of *Nypa fruticans* (nipa palm) biochar as an alternative, low-cost, and eco-friendly adsorbent for removal of these heavy metals from polluted water systems.

In this connection, we formally request your approval to grant access to the laboratory at the Natural Sciences² Laboratory for research purposes pertaining to our ongoing study. The laboratory will be utilized strictly for experiments necessary for this research, including sample preparation, and quantitative analysis. All experiments conducted will adhere to established laboratory protocols and safety guidelines to ensure compliance within institutional standards.

For further details, please refer to the attached file.

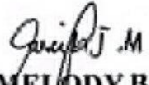
Thank you very much. Hoping for your positive response on this matter.

APPENDIX A Cont'd

Respectfully,


ALONAH IBARRA M. CARLOS
BS MedTech


KATHLEEN FAYE C. PABRIGA
BS MedTech

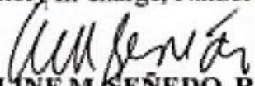

JANANE MELODY B. GARCIA
BS MedTech


JEMEL FRITZ D. VILLANTEZ
BS MedTech

Noted by:


DARWIN R. TAYLARAN, LPT
Research Adviser

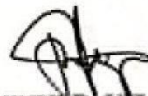

ARJADE O. ALCABAZA, LPT, RChT
Laboratory In-charge, NatSci


EVANGELINE M. SEÑEDO, RMT, MATMRS
Dean, College of Medical Technology

Recommending Approval:


NELFA D. CANINI, PhD.
Chair, Department of Natural Sciences

Approved by:


HAYDEE D. VILLANUEVA, PhD.
Dean, College of Arts and Sciences

APPENDIX B

Participants letter of consent

	MISAMIS UNIVERSITY Ozamiz City Department of Student Affairs & Services
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MU-DSAS-006/02 June 2023

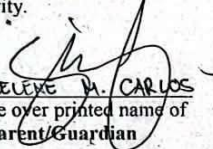
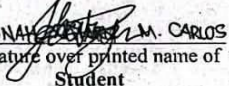
PARENT'S CONSENT

COLLEGE OF MEDICAL TECHNOLOGY
Sponsoring Group/Organization

I am allowing my son/daughter/ward, Alonah Jory M. Carlos, to join the Research Data Collection and Experimentation (activity) to be held on February - March, 2026 at Misamis University under the supervision of Darwin R. Taylaran (Adviser/Faculty).

I understand that Misamis University exercises the necessary safety precautions in this activity.

In consideration of the benefits to be derived from the above activity, I expressly waive any and all claims against the administration or any member of the faculty and staff of the Misamis University on account of any unforeseen accident or injury that my son/daughter/ward might incur in connection with the aforementioned activity.

 <u>JACKIELEVE M. CARLOS</u> Signature over printed name of Parent/Guardian	<u>1/18/26</u> Date
 <u>ALONAH JORY M. CARLOS</u> Signature over printed name of Student	<u>1/18/26</u> Date

Important: This form shall be submitted to the DSAS Office at least two (2) days before the conduct of the activity.

Ozamiz City

SUBSCRIBED AND SWORN to before me, this JAN 22 2026 at _____, Philippines, that the herein affiant personally came and appeared with his/her _____, as evidence of his/her personal identity.

Doc. No. <u>468</u> Page No. <u>17</u> Book No. <u>18</u> Series of 20 <u>24</u>	ATTY. EET B. BINIG, RMT Notarial Commission No. 2025-18 Notary Public for Ozamiz City and Clarin City Hall Drive, Bernad Subdivision, Aguada, Ozamiz City PTR No. 6007751; 01/05/2026; Ozamiz City IBP O.R. No. 576165; 12/29/2025; Pasig City Attorney's Roll No. 70648 MCLC Compliance No. VIII-0014127; Valid until 04/14/2028	Notary Public Until _____ PTR No. _____ IBP No. _____ TIN No. _____ Roll No. _____
---	---	---

(For DSAS Personnel only)

Attested by:

RODEL L. BALDADO, MHist, MAEd
OIC, Department of Student Affairs & Services
Date: _____

APPENDIX B Cont'd

	MISAMIS UNIVERSITY Ozamiz City Department of Student Affairs & Services
---	--

MU-DSAS-006/02June2023

PARENT'S CONSENT

College of Medical Technology
Sponsoring Group/Organization

I am allowing my son/daughter/ward, Dorothy H. Espanillo, to join the sample gathering phase of the research study (activity) to be held on January to April 2024 at Misamis University under the supervision of Ms. Shaira Alaina U. Guaman (Adviser/Faculty).

I understand that Misamis University exercises the necessary safety precautions in this activity.
In consideration of the benefits to be derived from the above activity, I expressly waive any and all claims against the administration or any member of the faculty and staff of the Misamis University on account of any unforeseen accident or injury that my son/daughter/ward might incur in connection with the aforementioned activity.

CIGI ANN ESPANILLO
Signature over printed name of
Parent/Guardian

Jan. 20, 2024
Date

DOROTHY ESPANILLO
Signature over printed name of
Student

Jan. 20, 2024
Date

Important: This form shall be submitted to the DSAS Office at least two (2) days before the conduct of the activity.

SUBSCRIBED AND SWORN to before me, this 20 day of Jan at Ozamiz City, Philippines, that the herein affiant personally came and appeared with his/her _____, as evidence of his/her personal identity.

Doc. No. 289
Page No. 28
Book No. 12
Series of 20 24

ATTY. RIZ B. BIRAG, JR.
Notarial Commission No. 2023-18
Notary Public for Ozamiz City and Clarin
City Hall Drive, Bernad Subdivision, Agosde, Ozamiz City
PTR No. 0007751; 01/05/2026; Ozamiz City
IBP O.R. No. 572166; 12/29/2026; Pasig City
Attorney's Roll No. 70648
MCLE Compliance No. VIII-0014127; Valid until 04/14/2028

Notary Public

Until _____
PTR No. _____
IBP No. _____
TIN No. _____
Roll No. _____

(For DSAS Personnel only)

Attested by:

RODEL BALDADO, MHist, MAEd
OIC, Department of Student Affairs & Services

Date: _____

APPENDIX B Cont'd

	MISAMIS UNIVERSITY Ozamiz City Department of Student Affairs & Services
---	--

MU-DSAS-006/02June2023

PARENT'S CONSENT

College of Medical Technology
Sponsoring Group/Organization

I am allowing my son/daughter/ward, Rhync Gwenn J. Galgo, to join the sample gathering part of the research study (activity) to be held on January to April 2026 at Misamis University under the supervision of Ms. Shaira Klaina U. Gulaman (Adviser/Faculty).

I understand that Misamis University exercises the necessary safety precautions in this activity.

In consideration of the benefits to be derived from the above activity, I expressly waive any and all claims against the administration or any member of the faculty and staff of the Misamis University on account of any unforeseen accident or injury that my son/daughter/ward might incur in connection with the aforementioned activity.

RIZA GALGO
Signature over printed name of
Parent/Guardian

Jan. 20, 2026
Date

RHYNE GWENN J. GALGO
Signature over printed name of
Student

Jan. 20, 2026
Date

Important: This form shall be submitted to the DSAS Office at least two (2) days before the conduct of the activity.

SUBSCRIBED AND SWORN to before me, this 20 day of January 2026 at Ozamiz City, Philippines, that the herein affiant personally came and appeared with his/her _____, as evidence of his/her personal identity.

Doc. No. 180
Page No. 58
Book No. W
Series of 20

ATTY. REY B. BINAG, RM1
Notarial Commission No. 2425-18
Notary Public for Ozamiz City and Clarin
City Hall Drive, Darnad Subdivision, Agurda, Ozamiz City
PTR No. 607751; 01/05/2026; Ozamiz City
IBP O.R. No. 576105; 12/29/2025; Pasig City
Attorney's Roll No. 70848
MCLE Compliance No. VIII-0014127; Valid until 04/14/2028

Notary Public
Until _____
PTR No. _____
IBP No. _____
TIN No. _____
Roll No. _____

(For DSAS Personnel only)

Attested by:

RODEL L. BALDADO, MHist, MAEd
OIC, Department of Student Affairs & Services

Date: _____

APPENDIX B Cont'd

	MISAMIS UNIVERSITY Ozamiz City Department of Student Affairs & Services
---	--

MU-DSAS-006/02 June 2023

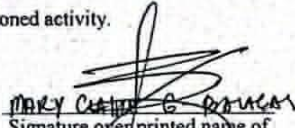
PARENT'S CONSENT

MEDICAL TECHNOLOGY
Sponsoring Group/Organization

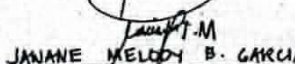
I am allowing my son/daughter/ward, JAWANE MELODY B. GARCIA, to join the RESEARCH DATA COLLECTION AND EXPERIMENTAL (Activity) to be held on February - March, 2026 at Misamis University under the supervision of DAKWIN R. TAYLARAN (Adviser/Faculty).

I understand that Misamis University exercises the necessary safety precautions in this activity.

In consideration of the benefits to be derived from the above activity, I expressly waive any and all claims against the administration or any member of the faculty and staff of the Misamis University on account of any unforeseen accident or injury that my son/daughter/ward might incur in connection with the aforementioned activity.


 Signature over printed name of
 Parent/Guardian

1/21/2026
Date


 Signature over printed name of
 Student

1/21/2026
Date

Important: This form shall be submitted to the DSAS Office at least two (2) days before the conduct of the activity.

SUBSCRIBED AND SWORN to before me, this JAN 22, 2026 at Ozamiz City, Philippines, that the herein affiant personally came and appeared with his/her _____, as evidence of his/her personal identity.

Doc. No. 46
 Page No. 3
 Book No. IX
 Series of 20 24

ATTY. REY D. B. NAG, RMT
 Notaria Commission No. 2025-18
 Notary Public for Ozamiz City and Clarin
 City Hall Drive, Bernad Subdivision, Aguada, Ozamiz City
 PTR No. 6007751; 01/05/2026; Ozamiz City
 ISP O.R. No. 576185; 12/29/2025; Pasig City
 Attorney's Roll No. 70648
 MCLE Compliance No. VIII-0014127; Valid until 04/14/2028

Notary Public
 Until _____
 PTR No. _____
 ISP No. _____
 TIN No. _____
 Roll No. _____

(For DSAS Personnel only)

Attested by:

RODEL L. BALDADO, MHist, MAEd
 OIC, Department of Student Affairs & Services

Date: _____

APPENDIX B Cont'd

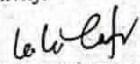
	MISAMIS UNIVERSITY Ozamiz City Department of Student Affairs & Services
MU-DSAS-006/02Jme2023	

PARENT'S CONSENT

COLLEGE OF MEDICAL TECHNOLOGY
 Sponsoring Group/Organization

I am allowing my son/daughter/ward, KATHLEEN FAYE C. PADRICA, to join
 the Research Data Collection and Experimentation (activity) to be held on
February - March, 2020 at Misamis University under the supervision of
Darwin R. Tayaran (Adviser/Faculty).

I understand that Misamis University exercises the necessary safety precautions in this activity.
 In consideration of the benefits to be derived from the above activity, I expressly waive any and all
 claims against the administration or any member of the faculty and staff of the Misamis University on
 account of any unforeseen accident or injury that my son/daughter/ward might incur in connection with
 the aforementioned activity.


GLORY GRACE CORTES
 Signature over printed name of
 Parent/Guardian

01/18/20
 Date


KATHLEEN FAYE PADRICA
 Signature over printed name of
 Student

01/18/20
 Date

Important: This form shall be submitted to the DSAS Office at least two (2) days before the conduct of the activity.

Ozamiz City

SUBSCRIBED AND SWORN to before me, this JAN 22 2020 day of _____ at _____
 Philippines, that the herein affiant personally came and appeared with his/her _____, as evidence of
 his/her personal identity.

ATTY. ROLAND B. BINAG, RMT
 Notarial Commission No. 7025-18
 Notary Public for Ozamiz City and Clarin
 City Hall Drive, Bernad Subdivision, Aguada, Ozamiz City
 PTR No. 6007751; 01/05/2026; Ozamiz City
 IBP O.R. No. 576165; 12/23/2025; Pasig City
 Attorney's Roll No. 70848
 MCLE Compliance No. VIII-0014127; Valid until 04/14/2028

Notary Public

Until _____
 PTR No. _____
 IBP No. _____
 TIN No. _____
 Roll No. _____

Doc. No. 409
 Page No. 83
 Book No. 18
 Series of 20 74

(For DSAS Personnel only)

Attested by:

RODEL L. BALDADO, MHist, MAEd
 OIC, Department of Student Affairs & Services
 Date: _____

APPENDIX B Cont'd



MISAMIS UNIVERSITY
Ozamiz City
Department of Student Affairs & Services

MU-DSAS-006/02/June2023

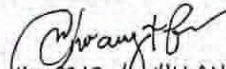
PARENT'S CONSENT

COLLEGE OF MEDICAL TECHNOLOGY
Sponsoring Group/Organization

I am allowing my son/daughter/ward, Jemel Fritz D. Villantez, to join the Research Data Collection and Experimentation (activity) to be held on February - March, 2026 at Misamis University under the supervision of Darwin R. Torglaran (Adviser/Faculty).

I understand that Misamis University exercises the necessary safety precautions in this activity.

In consideration of the benefits to be derived from the above activity, I expressly waive any and all claims against the administration or any member of the faculty and staff of the Misamis University on account of any unforeseen accident or injury that my son/daughter/ward might incur in connection with the aforementioned activity.


HERIBERTO VILLANTEZ
Signature over printed name of
Parent/Guardian

1/18/26

Date


JEMEL FRITZ D. VILLANTEZ
Signature over printed name of
Student

1/18/26

Date

Important: This form shall be submitted to the DSAS Office at least two (2) days before the conduct of the activity.

JAN 22 2026

Ozamiz City

SUBSCRIBED AND SWORN to before me, this ____ day of _____ at _____, Philippines, that the herein affiant personally came and appeared with his/her _____ as evidence of his/her personal identity.

ATTY. REY B. MINAG, RMT

Notarial Commission No. 2025-18

Notary Public for Ozamiz City and Clarin

City Hall Drive, Baroad Subdivision, Aguada, Ozamiz City

PTR No. 6007751; 01/05/2026; Ozamiz City

IBP O.R. No. 578185; 12/29/2025; Pasig City

/ Attorney's Roll No. 70848

MCLE Compliance No. VIII-0914127; Valid until 04/14/2028

Notary Public

Until

PTR No.

IBP No.

TIN No.

Roll No.

Doc. No. 411
Page No. 84
Book No. IX
Series of 2024

(For DSAS Personnel only)

Attested by:

RODEL L. BALDADO, MHist, MAEd

OIC, Department of Student Affairs & Services

Date: _____

APPENDIX C

Raw Data of the Result Provided by F.A.S.T. Laboratories



FOCUS ON EXCELLENCE • ADAPTABILITY TO CHANGE • SOCIAL RESPONSIBILITY • TEAMWORK • LEARNING AND GROWTH • ACCOUNTABILITY • BALANCED

F.A.S.T. Laboratories – CDO
Lapasan Hi-way corner Camp Alagar Road CDO City

Reference No. **CD2602-0918**
Page 1 of 2

TEST REPORT

CUSTOMER : ALONAH JHARY M. CARLOS
ADDRESS : Aguada, Sto. Niño, Village, Ozamiz City,
CONTACT PERSON : Alonah Jhary M. Carlos
CONTACT DETAILS : carlosjhary11@gmail.com
SAMPLE(S) SUBMITTED : SEAWATER (As Declared)
SAMPLE CODE : CD2602-0918-01
SAMPLED BY : Customer
SAMPLING LOCATION : Oroquieta
DATE / TIME OF SAMPLING : 12 February 2026 / 2:05 PM
DATE / TIME RECEIVED : 13 February 2026 / 9:55 AM
DATE ANALYZED : 05 – 08 March 2026
DATE REPORTED : 18 March 2026

Parameters	Unit	Results			Test Method
		Seawater without treatment			
		Trial 1	Trial 2	Trial 3	
Lead	mg/L	0.00854	0.00907	0.00867	3113 B. Electrothermal Atomic Absorption Spectrometry Method
Chromium	mg/L	Not Detected	Not Detected	Not Detected	

Note: Outsourced to F.A.S.T Laboratories' recognized subcontractor.

Method Detection Limit of Chromium= 0.006 mg/L

Reference: APHA-AWWA and WEF 2017. Standard Methods for the Examination of Water and Wastewater, 23rd ed.
APHA-AWWA and WEF 2023. Standard Methods for the Examination of Water and Wastewater, 24th ed.

Results are those obtained at time of examination and relate only to the sample(s) tested.

CERTIFIED BY:

M.R.T. SULLANO, RCh
Laboratory Supervisor
Chem. Reg. No. 0014490

APPROVED BY:

M.L.S. MENDOZA, RCh
Laboratory Business Manager
Chem. Reg. No. 08239

Terms and Conditions:

1. Sampling details such as sample description, sampling location/point, date and time of sampling are customer declared information which can affect the validity of results and the laboratory cannot confirm its accuracy and therefore should not be held liable.
2. This report is prepared for the **SOLE USE** of the customer and is prepared based on the item submitted, the services required by the customer and the conditions under which the Services are performed by F.A.S.T Laboratories. The report is not intended to be representative of similar or equivalent items and does not constitute an endorsement by F.A.S.T Laboratories on the item.
3. The report shall not be reproduced **EXCEPT IN FULL** and **SHALL NOT** be used for advertisement, publicity material, and press release or for litigation purposes **WITHOUT** the written permission of F.A.S.T Laboratories.
4. F.A.S.T Laboratories shall under no circumstances be liable to the customer or its representatives for any direct or indirect loss or damage suffered by the customer or its representatives howsoever arising or whether connected with the services provided by FAST Laboratories
5. This report is **NOT OFFICIAL** and **VALID** unless stamped with the seal of F.A.S.T Laboratories. It shall be kept on file for six (6) months from the date of issue.

ACCREDITATIONS/RECOGNITIONS: Dept. of Environment and Natural Resources (DENR) • Dept. of Health (DOH) • Dept. of Agriculture - Bureau of Animal Industry (DA-BAI)
Food and Drug Administration (FDA) • Bureau of Fisheries and Aquatic Resources (BFAR) • Laguna Lake Development Authority (LLDA)

MAIN: 62, 20th Avenue, Cubao, Quezon City, 1109 • Tels. (02) 8912-0250- 8912-5275 • Globe 0917-421-2629 • www.fastlaboratories.com.ph • info@fastlaboratories.com.ph • mktgsales.fastlaboratories@gmail.com
BRANCHES: CALABARZON – B1 L2 P1 Poste Verde de Sto. Tomas, Brgy. San Rafael, Sto. Tomas City, Batangas 4234 • Tels. (043)723-0424; 233-2797 • Globe (0917)-562-6249 • mktgsales.fastlaboratories@gmail.com
Cebu – Hi-way Central Bldg., M. C. Briones Highway, Mandaue City, Cebu 6014 • Tels. (032)-503-8272; Globe: (0917) 562-6322 • E-mail: mktgsales.fastlaboratories@gmail.com
Cagayan de Oro – 2/F Casho Bldg., C.M. Recto Ave., cor. Camp Alagar Rd., Brgy. Lapasan, Cagayan de Oro City, Misamis Oriental 9000 • Tels. (088)852-4846; (0917)624-6321 • mktgsales.fastlaboratories@gmail.com
Clark – Angeles – Sta 5.6.7, SNB Bldg., 717 Magalang Road, Pandan, Angeles City 2009 • Tels. (045)457-0517 • Globe: (0917) 108-8463 • mktgsales.fastlaboratories@gmail.com

APPENDIX C Cont'd



FOCUS ON EXCELLENCE • ADAPTABILITY TO CHANGE • SOCIAL RESPONSIBILITY • TEAMWORK • LEARNING AND GROWTH • ACCOUNTABILITY • BALANCED

F.A.S.T. Laboratories – CDO
Lapasan Hi-way corner Camp Alagar Road CDO City

Reference No. CD2602-0918

Page 2 of 2

TEST REPORT

CUSTOMER : ALONAH JHARY M. CARLOS
ADDRESS : Aguada, Sto. Niño, Village, Ozamiz City,
CONTACT PERSON : Alonah Jhary M. Carlos
CONTACT DETAILS : carlosjhary11@gmail.com
SAMPLE(S) SUBMITTED : SEAWATER (As Declared)
SAMPLE CODE : CD2602-0918-02
SAMPLED BY : Customer
SAMPLING LOCATION : Oroquieta
DATE / TIME OF SAMPLING : 12 February 2026 / 2:05 PM
DATE / TIME RECEIVED : 13 February 2026 / 9:55 AM
DATE ANALYZED : 05 – 08 March 2026
DATE REPORTED : 18 March 2026

Parameters	Unit	Results			Test Method
		Seawater with treatment			
		Trial 1	Trial 2	Trial 3	
Lead	mg/L	Not Detected	Not Detected	Not Detected	3113 B. Electrothermal Atomic Absorption Spectrometry Method
Chromium	mg/L	Not Detected	Not Detected	Not Detected	

Note: Outsourced to F.A.S.T. Laboratories' recognized subcontractor

Reporting Limit of Lead = 0.005 mg/L
Method Detection Limit of Chromium = 0.006 mg/L

Reference: APHA-AWWA and WEF 2017, Standard Methods for the Examination of Water and Wastewater, 23rd ed.
APHA-AWWA and WEF 2023, Standard Methods for the Examination of Water and Wastewater, 24th ed.

Results are those obtained at time of examination and relate only to the sample(s) tested.

CERTIFIED BY:
M.R.T. SULLANO, RCh
Laboratory Supervisor
Chem. Reg. No. 0014490

APPROVED BY:
M.L.S. MENDOZA, RCh
Laboratory Business Manager
Chem. Reg. No. 08239

Terms and Conditions:

1. Sampling details such as sample description, sampling location/point, date and time of sampling are customer declared information which can affect the validity of results and the laboratory cannot confirm its accuracy and therefore should not be held liable.
2. This report is prepared for the **SOLE USE** of the customer and is prepared based on the item submitted, the services required by the customer and the conditions under which the Services are performed by F.A.S.T. Laboratories. The report is not intended to be representative of similar or equivalent items and does not constitute an endorsement by F.A.S.T. Laboratories on the item.
3. The report shall not be reproduced **EXCEPT IN FULL** and **SHALL NOT** be used for advertisement, publicity material, and press release or for litigation purposes **WITHOUT** the written permission of F.A.S.T. Laboratories.
4. F.A.S.T. Laboratories shall under no circumstances be liable to the customer or its representatives for any direct or indirect loss or damage suffered by the customer or its representatives howsoever arising or whether connected with the services provided by FAST Laboratories
5. This report is **NOT OFFICIAL** and **VALID** unless stamped with the seal of F.A.S.T. Laboratories. It shall be kept on file for six (6) months from the date of issue.

ACCREDITATIONS/RECOGNITIONS: Dept. of Environment and Natural Resources (DENR) • Dept. of Health (DOH) • Dept. of Agriculture • Bureau of Animal Industry (DA-BAI)
Food and Drug Administration (FDA) • Bureau of Fisheries and Aquatic Resources (BFAR) • Laguna Lake Development Authority (LLDA)

MAIN: 62, 20th Avenue, Cebu, Cebu City, 6100 • Tel: (03) 5912-0250 • 8912-5275 • Globe: 0917-621-2625 • www.fastlaboratories.com.ph • info@fastlaboratories.com.ph • mktg@fastlaboratories.com.ph • mktg@fastlaboratories.com.ph
BRANCHES: CALABARZON - 8112 P1 Pinar Verde de Sto. Tomas, Brgy. San Roque, Sto. Tomas City, Batangas 4234 • Tel: (043) 723-0424, 233-2797306 • (0917) 562-4249 • mktg@fastlaboratories.com.ph
Cebu - Highway Central Bldg., M. C. Briones Highway, Marikina City, Cebu 6016 • Tel: (032) 503-4272 • Globe: (0917) 562-4022 • E-mail: mktg@fastlaboratories.com.ph
Cagayan de Oro - 2F Cusano Bldg., C.M. Recto Ave., cor. Carpio Alagui Rd., Brgy. Lacsua, Cagayan de Oro City, Misamis Oriental 9000 • Tel: (086) 852-4446 • (0917) 634-8321 • mktg@fastlaboratories.com.ph
Clark - Angeles - 398 5.6.7 RHE Bldg., 717 Magellan Road, Pandan, Angeles City, 2109 • Tel: (045) 457-0917 • Globe: (0917) 106-0463 • mktg@fastlaboratories.com.ph

APPENDIX C Cont'd Computation

Using the formula:

$$\text{Adsorption Capacity (q)} = \frac{(C_i - C_f)V}{m}$$

where:

- $V = 2\text{L}$
- $m = 3\text{g}$
- $C_f = 0 \text{ mg/L}$ (since the treated samples were reported as **ND**. In adsorption studies, researchers commonly assume $C_f = 0$ **only for the purpose of calculating adsorption capacity**, while stating that the concentration was below the detection limit.)

Calculations:

Trial 1

$$q = \frac{(0.00854 - 0) \times 2}{3} = 0.00569 \text{ mg/g}$$

Removal Efficiency:

$$\frac{0.00854 - 0}{0.00854} \times 100 = 100\%$$

Trial 2

$$q = \frac{(0.00907 - 0) \times 2}{3} = 0.00605 \text{ mg/g}$$

Removal Efficiency: 100%

Trial 3

$$q = \frac{(0.00867 - 0) \times 2}{3} = 0.00578 \text{ mg/g}$$

Removal Efficiency: 100%

Mean adsorption capacity:

$$\frac{0.00569 + 0.00605 + 0.00578}{3} = 0.00584 \text{ mg/g}$$

APPENDIX C Cont'd

Sample Standard Deviation formula:

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$

$$s = \sqrt{\frac{(0.00569 - 0.00584)^2 + (0.00605 - 0.00584)^2 + (0.00578 - 0.00584)^2}{3 - 1}}$$

Trial	x_i	$x_i - \bar{x}$	$(x - \bar{x})^2$
1	0.00569	-0.00015	0.0000000225
2	0.00605	0.00021	0.0000000441
3	0.00578	-0.00006	0.0000000036

Sum of Squares

$$0.0000000225 + 0.0000000441 + 0.0000000036 = 0.0000000702$$

$$\frac{0.0000000702}{2} = 0.000187$$

Take the square root:

$$s = \sqrt{0.0000000351} = 0.000187$$

Rounded off to five decimals:

$$s = 0.00019 \text{ mg/g}$$

Therefore, the result is:

$$0.00584 \pm 0.00019 \text{ mg/g}$$

APPENDIX D

Documentation



D.1 Collection of Seawater Sample

APPENDIX D Cont'd



D.2 Collection of Seawater Sample

APPENDIX D Cont'd



D.3 Preparation and collection of *N. fruticans*.

APPENDIX D Cont'd



D.4 Pyrolyzing of *N. fruticans*

APPENDIX D Cont'd



D. 5 Biochar with treatment

APPENDIX D Cont'd



D.6 Filtration of Biochar with treatment

APPENDIX E

Turnitin Results



Page 2 of 36 - Integrity Overview

Submission ID trn:oid::28447:146594318

21% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

✦ Bibliography

Match Groups

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Matches with neither in-text citation nor quotation marks
-  **10 Missing Quotations 1%**
Matches that are still very similar to source material
-  **0 Missing Citation 0%**
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Top Sources

- 9%  Internet sources
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Integrity Flags

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Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

APPENDIX F

Grammarly Results

General metrics

38,060	5,626	387	22 min 30 sec	43 min 16 sec
characters	words	sentences	reading time	speaking time

Score



This text scores better than 99%
of all texts checked by Grammarly

Writing Issues

4	3	1
Issues left	Critical	Advanced

Plagiarism

This text hasn't been checked for plagiarism

CURRICULUM VITAE

ALONAH JHARY M. CARLOS

Birthdate: April 5, 2004
Home Address: Purok-11, Santo Niño Village, Ozamiz City
Contact Number: 09276188688
E-mail Address: carlosjhary11@gmail.com

EDUCATIONAL BACKGROUND

Tertiary School: Bachelor of Science in Medical Technology
Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2023-2027)

Secondary School: Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2021-2022)
Ozamiz City National High School Lam-an,
Ozamiz City
(2020-2021)

Primary School: Ozamiz Montessori Center
Ozamiz City (2014-2017)
Misamis Union High School
Circumferential Road Lam-an, Ozamiz City
(2011-2013)

CURRICULUM VITAE

DOROTHY M. ESPANILLO

Birthdate: March 21, 2005

Home Address: 11-E Gallardo Street Ozamiz City, Misamis Occidental

Contact Number: 09999007915

E-mail Address: dorothyspanillo21@gmail.com

EDUCATIONAL BACKGROUND

Tertiary School: Bachelor of Science in Medical
Technology Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2023-2027)

Secondary School: Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2017-2023)

Primary School: Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2014-2017)

CURRICULUM VITAE

RHYNE GWENN J. GALGO

Birthdate: November 29, 2004
Home Address: Riverside Tambulig, Zamboanga del Sur
Contact Number: 09122925091
E-mail Address: rhynegwenngalgo@gmail.com

EDUCATIONAL BACKGROUND

Tertiary School: Bachelor of Science in Medical Technology Misamis
University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2022-2027)

Secondary School: Tambulig National High School
Lo. Iodiong Tambulig, Zamboanga del Sur (2017-2020)
Molave Vocational Technical School
Burgos St., Brgy Makugihon, Molave, Zamboanga del Sur
(2021-2023)

Primary School: Tambulig Central Elementary School-SPED
Happy Valley, Tambulig, Zamboanga del Sur

CURRICULUM VITAE

JANANE MELODY B. GARCIA

Birthdate: July 2, 2004
Home Address: Purok-1, San Jose, Bagakay, Ozamiz City
Contact Number: 09171832840
E-mail Address: garciajananemelody@gmail.com

EDUCATIONAL BACKGROUND

Tertiary School: Bachelor of Science in Medical
Technology Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2022-2027)

Secondary School: Bansarvil National High School
Bansarvil-1, Kapatagan, Lanao Del Norte, Philippines
(2020-2022)

Primary School: Bansarvil Elementary School
Bansarvil-1, Kapatagan, Lanao Del Norte, Philippines
(2011-2016)

CURRICULUM VITAE

KATHLEEN FAYE C. PABRIGA

Birthdate: June 9, 2004
Home Address: Purok-8, Olarioville, Calabayan, Ozamiz City
Contact Number: 09850086740
E-mail Address: kathleenfayecortes@gmail.com

EDUCATIONAL BACKGROUND

Tertiary School: Bachelor of Science in Medical
Technology Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2022-2027)

Secondary School: Ozamiz City School of Arts and Trades
Maningcol, Ozamiz City (2021-2022)
Tangub City National High School
Mantic, Tangub City
(2016-2021)

Primary School: Tigbao Central Elementary School
Poblacion Tigbao, Zamboanga del Sur
(2015-2016)
Tangub City Central School
Malubog, Tangub City (2013-2015)

CURRICULUM VITAE

JEMEL FRITZ D. VILLANTEZ

Birthdate: August 29, 2004

Home Address: Purok-1, Canicapan, Clarin, Misamis Occidental, Philippines

Contact Number: 09306498277

E-mail Address: jemelvillantez@gmail.com

EDUCATIONAL BACKGROUND

Tertiary School: Bachelor of Science in Medical Technology
Misamis University
H.T. Feliciano Street Aguada, Ozamiz City, Philippines
(2023-2028)

Secondary School: Clarin National High School
Poblacion-3, Clarin, Misamis Occidental, Philippines
(2021-2023)

Primary School: Ozamiz City Seventh-Day Adventist Elementary School
Bernad Avenue, Ozamiz City
(2012-2017)