CHAPTER 1

CHAPTER 1

Nickel is widely used in processes like mining, electroplating, and manufacturing, and traces of it can enter aquatic environments. Because of its persistence and potential impact on living organisms,

The exploration of efficient and eco-friendly approaches to remove nickel from water has become an important area of scientific interest.

Recent reviews and experimental studies document nickel's widespread presence in industrial effluents and summarize its toxic effects on aquatic organisms and humans, underscoring the need for practical removal strategies **(Singh et al., 2024; Begum et al., 2022; GJESM, 2023)**

Local studies and environmental assessments have also documented nickel and other mining-related contaminants in Philippine waters and coastal areas—highlighting real cases where nickel exposure has affected aquatic environments and local communities and reinforcing the urgency of locally appropriate remediation methods **(Willis, 2023)**..

Research by **Kharkan et al. (2023) and Ostróżka et al. (2024)** demonstrates that elevated nickel concentrations adversely affect fish physiology, disrupt reproductive processes, and alter aquatic community structures

In humans, prolonged exposure to high nickel levels is associated with respiratory, renal, and dermatological complications, and occupational exposure has been linked to carcinogenic risks **(Genchi et al., 2020).**

Among these, the banana (Musa spp.) The pseudostem has shown considerable promise due to its abundance, lignocellulosic composition, and functional groups capable of binding metal ions. The pseudostem is rich in cellulose, hemicellulose, and lignin, making it an effective material for adsorption processes, and it is widely available in banana-producing countries such as the Philippines, where it is often discarded as agricultural waste (**Acevedo et al., 2021; Pawar et al., 2023).**

Despite these encouraging findings, significant gaps remain that limit the practical application of banana pseudostem-derived adsorbents for nickel removal at scale.

Prior studies differ in preparation methods, activation or modification processes, contact times, initial metal concentrations, and dosages, making cross-study comparison challenging **(Saravanan et al., 2024).**

CHAPTER 2

BANANA PSEUDOSTEM -BADANAYAK ET AL AND HOSSAIN ET AL

Banana pseudostem is an agricultural by-product produced after banana harvesting and is commonly treated as waste despite its potential industrial and environmental value. Structurally, it is composed of tightly packed leaf sheaths that form a fibrous, water-rich, and lignocellulosic biomass containing functional groups such as hydroxyl and carboxyl groups that enhance contaminant interaction
(Badanayak et al., 2023)

- **Badanayak** talks about the lignocellulosic characteristics and functional groups such as carboxyl and hydroxyl groups which enhance the contaminant interactions or binds metal ions

Literature consistently describes banana pseudostem as abundant, renewable, biodegradable, and low-cost, making it suitable for sustainable technologies
(Hossain et al., 2024).

- **Hossain et al** talks about its practical and economic feasibility

Quantitative studies support the adsorptive capability of banana pseudostem for heavy metal removal
Bagali et al. (2017) conducted batch adsorption experiments using banana pseudostem powder for Pb(II) removal under varying pH, adsorbent dosage, initial metal concentration, and contact time. The results showed a maximum adsorption capacity of 34.21 mg g^{-1} based on the Langmuir isotherm model

- **BagalI et al** has a quantitative study using banan pseudostem pero lead then varying ph , adsorbent dosage, initial concentration and contact time

STRUCTURAL COMPOSITION OF BANANA PSEUDOSTEM
(BADANAYAK ET AL AND LI ET AL)
Banana pseudostem fibers are classified as lignocellulosic biomass and are primarily composed of cellulose (55–65%), hemicellulose (15–25%), and lignin (10–15%), which define their structural and functional properties **(Badanayak et al., 2023; Li et al., 2018).**

MOISTURE CONTENT(JAITRONG &MANTHEY ET AL, AND GUPTA ET AL)

Banana pseudostem contains over 90% water

. Both Jaitrong and Manthey (2023) and Gupta et al. (2024) describe banana pseudostem as having extremely high moisture content, which underscores the importance of pre-treatment, particularly drying, to improve structural integrity and expose surface functional groups.

Why did u dry the pseudostem

- Reducing the moisture content of banana pseudostem enhances its stability and increases effective surface area, improving its interaction with pollutants. Drying not only prepares the material for experimental processing but also optimizes its physical and chemical properties, thereby improving adsorption efficiency for heavy metals such as lead and chromium **(Balakrishan et al., 2021)**

Previous studies on banana pseudostem waste

Banana pseudostem is one of the most abundant agricultural by-products generated after banana harvesting in the Philippines, yet it is largely discarded as waste despite its potential applications. Literature consistently reports that vast quantities of banana pseudostem are left unused or burned after harvest, contributing to inefficient agricultural residue management and environmental burden **(Pannala & Karunarathne, 2022; Li et al., 2018).**

- **Studies by (Pannala & Karunarathne, 2022; Li et al., 2018).** Basically shows that in the philippines there is ton of pseudostem waste annually yet only small fraction is utilized for any secondary purpose

Application on banana pseudostem as a heavy metal adsorbent

Banana pseudostem is an abundant agricultural waste that can remove heavy metals from water due to its lignocellulosic composition. **Pawar et al. (2023)** reported that "the adsorption of lead(II) onto banana pseudostem powder… was fitted using the Langmuir adsorption isotherm," achieving a maximum adsorption capacity of 34.21 mg/g, and that the process followed pseudo-second-order kinetics, although removal efficiency in the column study was lower at 49% **(Pawar et al., 2023)**

- **Basically Pawar et al** in this context talks about that banana pseudostem can remove heavy metal from water due to its lignocellulosic composition

Nickel in water: sources and environmental impact

Nickel contamination in water is largely linked to industrial activities such as mining, metal processing, electroplating, industrial wastewater discharges, and runoff from manufacturing sites, where nickel-containing wastes enter aquatic environments and persist as dissolved Ni^{2+} ions **(Genchi et al., 2020; El-Naggar et al., 2021).** Once introduced into surface water or groundwater, nickel can remain mobile and accumulate in sediments or aquatic organisms, posing long-term threats to ecosystem stability and water quality.

- In this context el naggar and genchi et al talks about that nickel contamination is linked to industrial activities then it can enter the aquatic environments and persist as dissolved nickel ions….. And this can pose long term threats to ecosystem stability and water quality

Prolonged exposure to nickel-contaminated water has also been associated with adverse human health effects, including respiratory, renal, and dermatological problems, and nickel compounds have been linked to increased carcinogenic risks, particularly in populations living near industrial sites **(Genchi et al., 2020)**

- **Genchi** say that prolonged exposure to nickel can cause respiratory,renal and dermatological problems and nickel compound have been linked to carcinogenic risks

Microwave plasma atomic emission spectroscopy(MPAES) in nickel analysis

- an analytical technique increasingly used for quantitative determination of trace metals, including nickel, in water and environmental samples due to its sensitivity, multi-element capability, and cost-efficiency.
- **Jamari and Mohd Firdaus (2024)** demonstrated that MP-AES can detect heavy metals at sub-parts per billion levels in water and provide acceptable recovery results, making it suitable for water quality assessment.

Adsorbent dosage

Saravanan et al. (2024) explain that increasing adsorbent dosage generally enhances metal removal efficiency due to the increased availability of active binding sites and surface area for metal ion interaction. However, beyond an optimal dosage**, further increases may lead to particle aggregation and overlapping of adsorption sites, reducing adsorption efficiency per unit mass**.

- According to saravanan, increasing the dosage enhances removal capacity due to the increased available active binding sites and surface are for metal ion interaction—-- DOSE RESPONSE THEORY

Contact time

literature consistently describes that adsorption occurs rapidly at the initial stage as abundant active sites are available, followed by a slower approach to equilibrium as these sites become saturated **(Salihi et al., 2018; Rahman et al., 2023).**

Salihi et al (2018)- reported that copper(II) adsorption onto sludge activated carbon reached equilibrium after 12 hours

Rahman et al. (2023) -found that lead adsorption onto orange peel cellulose also reached equilibrium after 12 hours of contact

Aziam et al. (2024) -employed a 12-hour contact time in batch adsorption experiments

Percentage removal

Studies on nickel adsorption highlight percentage removal (%) as a key measure of how effective an adsorbent is, especially when using low-cost agricultural wastes.

Acheampong et al. (2023) found that banana peel–derived biochar can remove about 98–99% of nickel under optimized conditions. This high efficiency is due to its porous structure and abundant surface functional groups, which improve metal adsorption. The study shows that banana-based materials are highly promising for nickel removal when proper conditions, such as enough contact time and adsorbent amount, are met.

Adsorption Theory

The study is based on several theoretical frameworks:

Adsorption Theory

Explains how dissolved ions attach to solid surfaces (Bansal & Goyal, 2005).

Aqueous Solution Chemistry

Explains metal ion behavior in water (Atkins & de Paula, 2014).

Adsorption Isotherms

- **Langmuir model:** monolayer adsorption
- **Freundlich model:** multilayer adsorption (Foo & Hameed, 2010).

Dose–Response Theory

Increasing adsorbent dosage increases removal efficiency until saturation.

Circular Economy Theory

Circular Economy Theory is a concept in sustainability that focuses on **reducing waste and making the most out of resources** by keeping materials in use for as long as possible.

chapter 3

CHAPTER 3 – METHODOLOGY (Defense Summary)

Research Design

The study used a **quasi-experimental quantitative design** to evaluate adsorption performance at different dosages.

Three treatments were tested:

- 1 g/L
- 2 g/L
- 3 g/L

All experiments had **12-hour contact time**.

Research Environment

The study was conducted in the **Chemistry laboratories of Silliman University**, equipped with instruments such as **MP-AES for nickel concentration analysis**.

Samples and Treatments

Eight samples were prepared:

- 2 control samples
- 2 samples with **1 g/L adsorbent**
- 2 samples with **2 g/L adsorbent**
- 2 samples with **3 g/L adsorbent**

Duplicate trials ensured reliability.

Data Analysis

The following analyses were conducted:

1. **Residual Nickel Concentration**
2. **Percentage Removal**
3. **Maximum Adsorption Capacity**
4. **One-Way ANOVA**

ANOVA determines if differences among dosages are statistically significant.

CHAPTER 4

Level of acceptability of nickel concentrations

Table 1

Residual Nickel Concentration (mg/L) by Dosage

Dosage	Sample 1	Sample 2	Mean
1 g/L	52.33	51.34	51.84
2 g/L	46.10	47.50	46.80
3 g/l	46.86	45.46	46.16
Control	49.10	48.37	48.74

Mean residual nickel concentrations:

- **1 g/L: 51.84 mg/L-** the mean value of this is even higher than the control group, suggesting that the minimal amount of adsorbent may not have provided sufficient active surface area to facilitate nickel ion binding
  - this observation contradicts the findings of pawar et al(2023) and bagali et al (2017), which reported significantly higher removal efficiencies for heavy metals using banana pseudostem-based adsorbents. However, it should be noted that these studies investigated lead (Pb^{2+}) rather than nickel and were conducted under optimized conditions such as controlled pH and higher adsorbent surface activation. Thus, the present findings suggest that nickel adsorption behavior may differ from that of other heavy metals when interacting with untreated banana pseudostem fibers.

- **2 g/L:** 46.80 mg/L- the values remain significantly above the WHO guideline threshold.
  - The reduction indicates that increasing the adsorbent dosage improves nickel removal performance.

- Supports the adsorption theory discussed by Zhang et al. (2023) and Olufemi and Nnanna (2022), who found that increasing adsorbent dosage increases the number of available adsorption sites
- Similarly, the structural composition described by Badanayak et al. (2023)—particularly the presence of hydroxyl and carboxyl functional groups within the lignocellulosic matrix—suggests that these chemical groups can bind metal ions through mechanisms such as ion exchange and surface complexation.

3 g/L: 46.16 mg/L- which represents the lowest concentrations among all the experiment treatments

- While this result indicates improved nickel removal compared to the lower dosages, the reduction remains insufficient to meet regulatory safety limits.
- The persistence of relatively high residual concentrations may indicate that equilibrium between the dissolved nickel ions and the available adsorption sites was reached within the 12-hour contact period, aligns with the adsorption saturation principles discussed in biosorption literature

Control group: 48.74

The results demonstrate that increasing the dosage of banana pseudostem fibers resulted in measurable reductions in nickel concentration. This observation can be explained by adsorption theory, which posits that increasing the amount of adsorbent enhances the total surface area and the number of available active binding sites, thereby increasing the likelihood of interaction between metal ions and the adsorbent surface **(Saravanan et al., 2024; Olufemi & Nnanna, 2022).**

Percentage removal of nickel from aqueous solution

Mean Percentage removal:

- **1 g/L:** −3.67%- “no removal/ Ineffective’”, The negative removal values indicate that the measured nickel concentrations after treatment were slightly higher than the initial concentration. Such outcomes may arise from minor analytical variations, incomplete mixing, or desorption of trace metals present within the biomass itself

- therefore contradict the expected adsorption behavior described in the literature, particularly the findings o**f Bagali et al.,** which demonstrated substantial heavy metal removal using banana pseudostem powder.

- **2 g/L:** 6.40%- “Low removal ”- These values demonstrate a clear improvement compared to the 1 g/L treatment, suggesting that increasing the amount of adsorbent provides more available binding sites for nickel ions.
  - This observation supports adsorption principles outlined by **Zhang et al.,** which emphasize that higher adsorbent dosage typically enhances removal efficiency due to increased surface area and active adsorption sites.
    - The presence of hydroxyl and carboxyl functional groups within the lignocellulosic matrix of banana pseudostem fibers, as discussed by **Li et al. and Badanayak et al**., likely contributes to this adsorption process by facilitating electrostatic interactions and complexation with nickel ions

- **3 g/L:** 7.68%- “Low Removal",the trend indicates that increasing the adsorbent dosage enhances nickel uptake

- Control group: 2.53%- “Very Low Removal.”

Ultimately, the data reveals a positive dosage-response relationship, wherein increasing the amount of banana pseudostem adsorbent leads to higher nickel removal efficiency. This pattern aligns with adsorption theory regarding the importance of adsorbent mass in heavy metal biosorption

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Maximum Adsorption Capacity (mg/g) of Banana Pseudostem Adsorbents

Mean of adsorption capacity

- **1 g/L: -1.84 mg/g**.- Negative values correspond with the negative removal percentages observed earlier and indicate that the adsorbent at this dosage was unable to effectively capture nickel ions from the solution.
  - this observation therefore contradicts the adsorption capacities reported by **Pawar et al. (2023**) for banana pseudostem-based adsorbents, which recorded significantly higher adsorption performance under optimized conditions

- **2 g/L: 1.60 mg/g-** These results demonstrate measurable nickel adsorption and confirm that increasing the adsorbent mass improves adsorption capacity.
  - Positive results indicate that banana pseudostem fibers can effectively bind nickel ions due to their lignocellulosic structure. This is mainly because of surface functional groups like hydroxyl and carboxyl groups, which are known to play a key role in metal adsorption in biomass materials **(Li et al., 2018; Badanayak et al., 2023).**

- **3 g/L: 1.45 mg/g-** Even though this treatment used the highest amount of adsorbent, its adsorption capacity was slightly lower than the 2 g/L treatment. This can happen because too much adsorbent can cause particles to clump together, blocking some of the active sites. As a result, there is less surface area available to absorb nickel. Studies show that increasing the adsorbent amount can sometimes lower efficiency per unit because of crowding and slower movement of metal ions.

One-Way ANOVA Analysis on the Difference in Nickel Removal Among Dosages

- leading to the rejection of the null hypothesis. This statistical outcome indicates that at least one treatment group differed significantly from the others in terms of residual nickel concentration

Tukey post hoc

The Tukey test showed that 1 g/L is significantly different from both 2 g/L and 3 g/L, meaning increasing the dosage from 1 g/L clearly improves nickel removal. However, there is no significant difference between 2 g/L and 3 g/L, showing that adding more adsorbent beyond 2 g/L does not give meaningful improvement.

This means that while increasing adsorbent helps at first, it eventually reaches a limit where the effect levels off. This supports previous studies (Olufemi and Nnanna, 2022) and adsorption theory, which explain that after a certain point, adding more adsorbent leads to little to no improvement due to fewer available sites and system equilibrium.

Tab 5

Level of acceptability

This study examined bananas (Musa spp.) pseudostem as a low-cost and eco-friendly adsorbent for removing nickel from water. Results showed that increasing the adsorbent dosage (from 1 g/L to 3 g/L) generally reduced the amount of nickel left in the solution. The 3 g/L dosage had the lowest nickel concentration, followed closely by 2 g/L, while 1 g/L had the highest among the treated samples.

However, even with these reductions, all samples still had nickel levels far above the safe limit set by the World Health Organization (0.07 mg/L). This means that while the adsorbent has some effect, it is not enough on its own to make the water safe for drinking.

Percentage removal and maximum adsorption capacity

This study evaluated banana (Musa spp.) pseudostem as a low-cost and eco-friendly adsorbent for nickel removal in water. Increasing the adsorbent dosage from 1 g/L to 3 g/L generally decreased the residual nickel concentration, with 3 g/L showing the lowest level and 1 g/L the highest among treated samples.

However, despite these reductions, all results remained far above the World Health Organization standard of 0.07 mg/L. This indicates that while the adsorbent is effective to some extent, it is not sufficient on its own to reduce nickel to safe drinking levels.

A one-way ANOVA showed that nickel removal differed significantly among the three adsorbent dosages. Post-hoc tests indicated that the 1 g/L dosage was significantly less effective than 2 g/L and 3 g/L, while there was no significant difference between 2 g/L and 3 g/L. This led to rejecting the null hypothesis (H_0) and accepting the alternative (H_1), confirming that dosage affects nickel removal. Overall, banana pseudostem fibers can adsorb nickel, but further optimization is needed to improve their effectiveness.

Conclusion

- This study shows that banana (Musa spp.) pseudostem fibers have natural adsorption properties that allow them to reduce nickel ions in water, making them a low-cost and eco-friendly biosorbent. Increasing the adsorbent dosage improved nickel removal, highlighting the role of the fibrous lignocellulosic structure in binding metal ions. While the reduction did not meet WHO drinking water standards, the fibers could still serve as a preliminary or supplementary treatment.The limited effectiveness is likely due to the natural form of the fibers, high initial nickel levels, and lack of chemical activation or modification. Despite these limitations, the research demonstrates that agricultural byproducts like banana pseudostem can be repurposed as sustainable resources for environmental remediation. With further optimization, these fibers have the potential to provide accessible, cost-effective, and environmentally responsible solutions for reducing heavy metal contamination in water, particularly in communities with limited access to advanced treatment systems.

RECOMMENDATION

Public Health Sector:

- Conduct further studies to improve treatment conditions and adsorption techniques for nickel removal.
- Strengthen research on low-cost biosorbents to develop safer water purification methods and reduce health risks from heavy metal exposure.

Agricultural Industry:

- Explore agricultural byproducts like banana pseudostems as sustainable raw materials for environmental remediation.
- Develop value-added uses for these materials to promote responsible waste management and provide farmers with innovative opportunities.

Environmental Agencies and Policymakers:

- Support research initiatives investigating locally available materials for water treatment.
- Promote pilot studies and community-level experiments to evaluate the practicality of biosorbent technologies, especially in industrial or mining-affected areas.

Local Communities:

- Implement awareness programs and collaborative environmental projects to encourage the responsible use of local resources for water quality improvement.
- Engage communities in sustainable environmental practices to strengthen long-term protection and improve access to safer water.

School Administrators and Academic Institutions:

- Integrate sustainability-based research projects into science education and research programs.

- Encourage students to investigate environmental solutions using agricultural waste to foster innovation, critical thinking, and environmental responsibility.

Future Researchers:

- Explore methods to enhance adsorption efficiency of banana pseudostem fibers, such as chemical activation, surface modification, longer contact time, higher dosages, or combined biosorbent systems.
- Conduct larger-scale experiments and optimize conditions to better assess the feasibility of banana pseudostem materials for heavy metal remediation.

DLSU

What You Need to Master

1. The Entire Study in One Minute

Memorize this:

> "Our study investigated whether banana pseudostem, an abundant agricultural waste material, can be used as a sustainable biosorbent for removing nickel from contaminated water. We tested three dosages (1, 2, and 3 g/L) under a fixed 12-hour contact time. Nickel concentrations were measured using MP-AES. Results showed increasing nickel removal with increasing dosage, with 3 g/L performing best. Although treated water did not yet meet WHO drinking-water standards, the findings demonstrate that banana pseudostem possesses measurable adsorption potential and could serve as a low-cost and environmentally sustainable remediation material with further optimization."

If you can confidently explain this in 45–60 seconds, you already look prepared.

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2. Master These Core Concepts

Adsorption

Question:
"What is adsorption?"

Answer:

> Adsorption is the attachment of molecules or ions onto the surface of a material rather than absorption into the material itself. In our study, nickel ions attach to the surface of banana pseudostem fibers.

Why Banana Pseudostem Works

Question:
"Why can banana pseudostem remove nickel?"

Answer:

> Banana pseudostem contains cellulose, hemicellulose, and lignin. These materials contain hydroxyl and carboxyl functional groups that can bind positively charged nickel ions through electrostatic attraction, ion exchange, and surface complexation.

Why Nickel?

This is one of the most likely questions.

Answer:

> Nickel is a priority pollutant because it persists in the environment, accumulates in aquatic organisms, and may cause respiratory, kidney, skin, and carcinogenic effects in humans. Nickel contamination is also associated with mining and industrial activities in the Philippines.

Why 12 Hours?

Answer:

> Literature shows that many biosorbents reach adsorption equilibrium around 12 hours. Using a fixed 12-hour contact time allowed us to standardize the experiment and ensure sufficient interaction between nickel ions and adsorption sites.

Why MP-AES?

Answer:

> MP-AES provides sensitive and reliable detection of nickel concentrations while being cost-effective and capable of analyzing multiple elements. It provides accurate measurements of residual nickel after treatment.

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3. Sustainability Questions (HIGHLY LIKELY)

These questions often decide winners.

Q: Why is your study sustainable?

Answer:

> Banana pseudostem is an agricultural waste product usually discarded after harvest. By converting waste into a water treatment material, we reduce waste generation while addressing water pollution simultaneously. This follows Circular Economy Theory.

Q: How does your study contribute to the Sustainable Development Goals (SDGs)?

Memorize:

- SDG 6 – Clean Water and Sanitation
- SDG 12 – Responsible Consumption and Production
- SDG 13 – Climate Action
- SDG 15 – Life on Land

Q: What makes your solution better than conventional methods?

Answer:

> Conventional methods can be expensive and require advanced technology. Banana pseudostem is locally available, renewable, biodegradable, and low-cost.

Q: Is your solution economically feasible?

Answer:

> Yes. Banana pseudostem is widely available in banana-producing regions and is often discarded as agricultural waste. The raw material cost is therefore minimal.

Questions That May Challenge You

Q: Your treated water still exceeded drinking water standards. Is your study a failure?

This is a trap question.

Answer:

> No. The study successfully demonstrated adsorption potential and established a dosage-response relationship. While the treated water did not yet meet drinking water standards, the findings show that banana pseudostem can remove nickel and provide a foundation for future optimization.

Q: Why were your removal percentages relatively low?

Answer:

Possible reasons:

- Raw pseudostem was used.
- No chemical activation was performed.
- Only a single contact time was tested.
- Nickel is difficult to remove compared to some other heavy metals.
- Limited dosage range.

Q: What would you improve if given another year?

Excellent answer:

1. Increase contact time.
2. Test higher dosages.
3. Chemically activate pseudostem.
4. Test real wastewater.
5. Conduct adsorption isotherm studies.

6. Scale up to pilot systems.

Common Congress Questions

Introduction

- Why did you choose this topic?
- Why nickel?
- Why banana pseudostem?
- What research gap did you identify?

Methodology

- Why quasi-experimental?
- Why only 3 dosages?
- Why duplicate samples?
- Why not use actual wastewater?
- Why use MP-AES?

Results

- Which dosage performed best?
- Were results statistically significant?
- What does ANOVA mean?
- Why did adsorption capacity behave that way?

Sustainability

- Is it scalable?
- Is it affordable?
- Can communities actually use it?
- What environmental impacts might result?

Future Applications

- Can it remove lead?
- Can it remove cadmium?
- Can it remove chromium?
- Can it be commercialized?
- Can it be integrated into filtration systems?

5-Day Intensive Study Plan

Day 1 – Foundation

Study:

- Introduction
- Background
- Statement of Problem
- Significance

Goal:

Be able to explain:

- Why nickel matters
- Why banana pseudostem matters
- Why sustainability matters

Day 2 – Literature Review

Study:

- Adsorption
- Banana pseudostem composition
- Nickel contamination
- Circular Economy Theory

Goal:

Answer every "Why?" question confidently.

Day 3 – Methodology Mastery

Study:

- Research design
- Sampling
- Preparation procedure
- MP-AES
- ANOVA

Goal:

Explain every methodological choice.

Day 4 – Results and Statistics

Memorize:

- Residual nickel concentrations
- Removal percentages
- Adsorption capacities
- Statistical significance

Goal:

No hesitation when discussing results.

Day 5 – Mock Defense Day

Have teammates ask:

- 50 random questions
- Sustainability questions
- Criticism questions
- Feasibility questions

Practice until every answer is under 60 seconds.

MOCK QUES

1. Why did you choose sustainability over maximum efficiency?

Answer

Our study prioritized sustainability because the objective was not only to remove nickel from water but also to evaluate whether an agricultural waste product could serve as a practical and environmentally responsible adsorbent. While activated carbon and chemically modified adsorbents may achieve higher removal efficiencies, they often require expensive processing and additional resources. Banana pseudostem is abundant, renewable, biodegradable, and typically discarded after harvest. Therefore, even if its adsorption performance is lower, it offers greater environmental and economic sustainability for resource-limited communities.

This aligns with **Circular Economy Theory**, which promotes transforming waste materials into valuable products rather than disposing of them (Kirchherr et al., 2017). It also supports sustainable resource utilization while reducing agricultural waste.

Theory

- Circular Economy Theory
- Sustainable Remediation Principle

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2. How does Circular Economy Theory specifically apply to your findings?

Answer

Circular Economy Theory states that waste materials should be reintegrated into productive use instead of being discarded. In our study, banana pseudostem—which is normally considered agricultural waste—was converted into a biosorbent for nickel remediation. Rather than allowing the pseudostem to become waste, we extended its useful life cycle by transforming it into a water treatment material.

Our findings demonstrate that agricultural by-products can have environmental value beyond their original purpose, supporting the circular economy model of reducing waste generation while addressing pollution problems simultaneously.

Theory

- Circular Economy Theory (Kirchherr et al., 2017)

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3. What is the environmental cost of preparing the adsorbent?

Answer

The environmental cost of our adsorbent preparation was relatively low because the preparation process involved washing, air-drying, blending, and sieving the banana pseudostem. Unlike activated carbon production, our methodology did not require high-temperature carbonization, chemical activation, or intensive energy consumption.

However, there are still environmental costs associated with water use during washing, electricity used for blending, and waste generated during preparation. Despite these costs, they remain significantly lower than many commercial adsorbent production processes.

Theory

- Life Cycle Thinking
- Circular Economy Theory

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4. What happens to the nickel-loaded pseudostem after treatment?

Answer

After adsorption, the nickel ions remain attached to the pseudostem surface. Therefore, the spent adsorbent should not simply be discarded into the environment because the adsorbed nickel may eventually be released.

Consistent with the principles of Republic Act No. 6969, the nickel-loaded pseudostem should be treated as potentially hazardous waste and disposed of through appropriate hazardous waste management procedures. Future studies could investigate regeneration techniques or metal recovery methods to further improve sustainability.

Theory

- RA 6969
- Environmental Risk Management

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5. Could seconda

ry contamination occur?

Answer

Yes. Secondary contamination is possible if the nickel-loaded pseudostem is improperly disposed of. Changes in environmental conditions such as pH, temperature, or microbial activity could potentially release adsorbed nickel back into the environment.

This is why proper disposal and management of spent adsorbents are important considerations in any adsorption-based treatment system. Although adsorption removes contaminants from water, it transfers them to another medium that must still be managed responsibly.

Theory

- Adsorption Theory
- Environmental Risk Assessment

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6. How would you scale this to a barangay-level water treatment system?

Answer

Scaling up would involve constructing a filtration column containing processed banana pseudostem adsorbent. Contaminated water could flow through multiple adsorption chambers before collection.

Because banana pseudostems are widely available in agricultural areas of the Philippines, barangays could locally source raw materials and reduce treatment costs. However, further studies would be required to determine optimal flow rates, regeneration cycles, maintenance requirements, and long-term performance under real wastewater conditions.

The scalability of the system is supported by the abundance and low cost of banana pseudostem materials.

Theory

- Circular Economy Theory
- Sustainable Engineering Principles

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7. How would climate change affect the applicability of your solution?

Answer

Climate change may increase the need for low-cost water treatment technologies due to increased flooding, extreme weather events, and pollution of freshwater sources. In agricultural countries such as the Philippines, climate-related water quality issues may increase heavy metal mobility and contamination risks.

Since banana production remains widespread in tropical regions, banana pseudostem could remain a readily available resource for decentralized water treatment systems. Therefore, climate change may actually increase the relevance of sustainable biosorbent technologies.

Theory

- Sustainable Development Framework
- Climate Adaptation Strategies

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8. What trade-offs exist between sustainability and adsorption performance?

Answer

> The primary trade-off is that sustainable biosorbents are often less efficient than highly engineered commercial adsorbents. Activated carbon, for example, generally has higher adsorption capacities due to its larger surface area and controlled pore structure.
>
> However, banana pseudostem offers advantages in affordability, renewability, biodegradability, and local availability. Our study therefore evaluates whether a moderate reduction in adsorption performance may be acceptable when balanced against significant sustainability benefits.

Theory

- Circular Economy Theory
- Cost-Benefit Analysis

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9. What is the life-cycle advantage of your biosorbent compared with activated carbon?

Answer

Activated carbon often requires carbonization at very high temperatures and may involve chemical activation, both of which increase energy consumption and production costs.

In contrast, banana pseudostem is a naturally occurring agricultural by-product that requires minimal processing. Its production generates fewer emissions, uses less energy, and simultaneously reduces agricultural waste.

From a life-cycle perspective, banana pseudostem demonstrates a lower environmental footprint while promoting resource recovery and waste valorization.

Theory

- Life Cycle Assessment
- Circular Economy Theory

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10. If you had ₱100,000 in funding, what would be your next experiment?

This is the answer that usually impresses judges the most.

Answer

If provided with ₱100,000 in funding, our next experiment would focus on optimizing adsorption performance through chemical activation and real-world validation.

Specifically, we would:

1. Compare raw and chemically activated banana pseudostem.
2. Test higher adsorbent dosages beyond 3 g/L.
3. Evaluate multiple contact times.
4. Perform adsorption isotherm studies using Langmuir and Freundlich models.
5. Test actual wastewater samples from industrial or mining areas.
6. Investigate regeneration and reuse of the adsorbent.

These experiments would help determine whether banana pseudostem can move beyond laboratory-scale testing toward practical implementation in community water treatment systems.

The single most important sustainability statement to memorize:

> "Our study is not simply about removing nickel. It is about transforming an agricultural waste product into a value-added environmental remediation material, demonstrating how sustainability and pollution control can be addressed through a single solution based on Circular Economy Theory."

The **main issue** in your study is:

> **Nickel contamination in water poses risks to human health and the environment, while many existing treatment methods can be costly or inaccessible. At the same time, banana pseudostems are often discarded as agricultural waste.**

Your study asks:

> **Can banana pseudostem be transformed into a sustainable, low-cost adsorbent capable of removing nickel from contaminated water?**

The problem broken down into three parts:

1. Environmental Problem

Nickel enters water through activities such as mining, metal processing, electroplating, and industrial wastewater discharge. Once present in water, nickel can persist in the environment and affect aquatic ecosystems.

2. Human Health Problem

Long-term exposure to elevated nickel concentrations may lead to respiratory, kidney, skin, and potentially carcinogenic effects. Because of these risks, organizations like the World Health Organization set limits for nickel in drinking water.

3. Sustainability Problem

Many effective treatment technologies can be expensive. Meanwhile, banana pseudostems are abundant agricultural by-products that are often discarded. Your study investigates whether this waste material can be repurposed into a useful water treatment material.

One-Sentence Defense Answer

If a judge asks **"What is the main issue your study addresses?"**, answer:

> "The main issue addressed by our study is the need for a sustainable and affordable method of removing nickel contamination from water while simultaneously utilizing banana pseudostem agricultural waste that would otherwise be discarded."

Even Stronger Congress-Level Answer

> "Our study addresses two interconnected environmental issues: nickel contamination in water and the underutilization of agricultural waste. We investigated whether banana pseudostem could serve as a low-cost biosorbent for nickel remediation, thereby contributing to both water quality improvement and sustainable waste utilization through Circular Economy Theory."

Short Answer

> Nickel does not naturally degrade because it is an element. Unlike organic pollutants, elements cannot be broken down into simpler substances by biological, chemical, or environmental processes. Instead, nickel can only change forms, move between environmental compartments, or bind to other substances.

Congress-Level Answer

> Nickel does not naturally degrade because it is a heavy metal and a chemical element. According to the law of conservation of matter, elements cannot be destroyed through ordinary environmental processes. While organic pollutants may decompose through microbial activity or chemical reactions, nickel remains present in the environment and can only change its chemical form or location. For example, dissolved nickel ions may adsorb onto sediments, accumulate in aquatic organisms, or bind to organic matter, but the nickel itself remains in existence. This persistence is one reason nickel is considered a priority pollutant and why remediation strategies such as adsorption are necessary.

If a Judge Asks a Follow-Up

"If nickel doesn't degrade, then what does your adsorbent actually do?"

Answer:

> Our banana pseudostem adsorbent does not destroy nickel. Instead, it removes nickel ions from the water by adsorbing them onto the surface of the pseudostem fibers. This transfers the nickel from the aqueous phase to the solid adsorbent phase, making the water cleaner and safer. However, the nickel-loaded adsorbent must still be managed properly because the nickel remains present on the adsorbent surface. This is why proper disposal and handling are important.

Easy Way to Remember

Think of it this way:

- **Food waste** → can decompose.
- **Paper** → can decompose.
- **Nickel metal** → cannot decompose because it is an element.

A phrase you can memorize:

> **"Nickel is not destroyed by nature; it is only transferred from one place or form to another."**
>
> "Our study focuses on the adsorption stage, which removes nickel from water by transferring it to the banana pseudostem adsorbent. However, adsorption does not eliminate nickel from existence; it only transfers the contaminant from the liquid phase to a solid phase. Therefore, proper management of the spent adsorbent is necessary."

Real-World Options for the Spent Adsorbent

Option 1: Hazardous Waste Disposal (Most Realistic)

For actual implementation:

> Once the banana pseudostem becomes saturated with nickel, it should be collected and disposed of as hazardous waste in accordance with Republic Act No. 6969 and applicable DENR regulations. This prevents the nickel from re-entering the environment through leaching.

Why this is the safest answer

Because your study did not investigate regeneration or metal recovery.

Judges appreciate when you acknowledge the limits of your research.

Best Defense Answer

If a DLSU judge asks:

"After adsorption, what happens to the nickel-loaded banana pseudostem?"

Answer:

> "After adsorption, the nickel remains attached to the surface of the banana pseudostem. Therefore, the spent adsorbent should be managed responsibly because the contaminant has been transferred rather than destroyed. In a real-world application, the safest approach would be disposal through approved hazardous waste management systems in accordance with RA 6969. Future studies could investigate regeneration and nickel recovery methods to further enhance sustainability and support circular economy principles."

The question behind the question

The judge is really asking:

> "Did you solve the nickel problem, or did you just move the nickel somewhere else?"

Your strongest response is:

> "Adsorption transfers the nickel from water to the adsorbent, making the water safer. Proper post-treatment management of the adsorbent is therefore essential, and this represents an important consideration for real-world implementation."

WHO GUIDELINE
We used the guideline established by the World Health Organization because it is an internationally recognized health-based standard developed from toxicological and epidemiological evidence. The WHO guideline of 0.07 mg/L for nickel in drinking water represents a concentration that is considered protective of human health over long-term exposure. Since our study aims to evaluate whether treated water reaches a level considered

safe for human consumption, the WHO guideline provides a scientifically credible benchmark for assessing the effectiveness of the banana pseudostem adsorbent.

If a Judge Asks:

"Why not just use percentage removal instead of WHO standards?"

Answer:

> Percentage removal only indicates how much nickel was removed relative to the initial concentration. However, it does not tell us whether the remaining nickel concentration is actually safe for human consumption. By comparing our results to the WHO guideline, we can evaluate not only treatment efficiency but also the practical safety and acceptability of the treated water. For example, a treatment could remove 90% of the nickel but still exceed the safe drinking water limit if the initial concentration was very high.

Theoretical Support

You can connect this to:

Public Health Risk Assessment

> Regulatory standards such as the WHO guideline are based on risk assessment principles, which aim to establish contaminant concentrations that minimize adverse health effects over a lifetime of exposure.

Environmental Health Theory

> Environmental health frameworks emphasize that the success of a remediation technology should not only be measured by contaminant reduction but also by whether the treated resource meets established health-protection standards.

One-Sentence Answer to Memorize

> "We used the WHO guideline because it is an internationally recognized, health-based standard that allows us to determine whether the treated water is not only cleaner, but also safe for human consumption."

Why is water contamination a global concern?

Water contamination is a global concern because it threatens human health, damages aquatic ecosystems, and reduces access to safe drinking water. As populations grow and industrial activities increase, maintaining water quality becomes essential for environmental sustainability and public health.

Why should society care about nickel contamination when there are other heavy metals?

Society should care about nickel contamination because nickel is widely used in industrial processes and can enter water systems through mining, metal processing, and wastewater discharge. Prolonged exposure to elevated nickel concentrations may cause adverse effects on human health and aquatic organisms, making it an important environmental pollutant.

Why focus on removing nickel instead of preventing contamination?

While preventing contamination is the ideal long-term solution, existing nickel contamination still remains in many water sources. Therefore, remediation technologies are necessary to address contamination that has already occurred and to protect public health and the environment.

If industries stopped releasing nickel today, would your study still matter?

Yes, our study would still remain relevant because nickel does not naturally degrade in the environment. Existing contamination can persist in water bodies, sediments, and ecosystems for extended periods, making remediation efforts necessary even after pollution sources have been controlled.

Why is Adsorption Theory important in your study?

Adsorption Theory is important because it explains the mechanism through which nickel ions are removed from water. The theory states that contaminants can attach to active sites on the surface of an adsorbent, which is the primary process being investigated in our study.

Why did you choose banana pseudostem?

We chose banana pseudostem because it is abundant, inexpensive, biodegradable, and commonly treated as agricultural waste. In addition, its cellulose-rich structure contains functional groups that can interact with nickel ions and facilitate adsorption.

Why not use activated carbon instead?

Although activated carbon is highly effective, it can be expensive and may require extensive processing. Banana pseudostem offers a more sustainable and potentially cost-effective alternative, especially for communities with limited resources.

Why did you use a quasi-experimental design?

A quasi-experimental design was appropriate because the study involved manipulating the dosage of banana pseudostem adsorbent and measuring its effect on nickel removal. However, the study did not involve random assignment of participants, making a quasi-experimental approach more suitable.

Why did you use three dosage levels?

The three dosage levels were selected to determine whether increasing the amount of adsorbent would result in greater nickel removal and to identify which dosage provided the best performance under the experimental conditions.

Why did you use duplicate samples?

Duplicate samples were used to improve the reliability and consistency of the results. Replication helps reduce the influence of random error and increases confidence in the findings.

Why was the contact time fixed at 12 hours?
The contact time was fixed at 12 hours to ensure consistency across all treatment groups and to provide sufficient time for nickel ions to interact with the adsorption sites on the banana pseudostem.

Why did you use distilled water instead of real wastewater?

Distilled water was used to eliminate interference from other contaminants and to isolate the effect of nickel. This allowed us to evaluate the adsorption performance of banana pseudostem under controlled laboratory conditions.

Why is ANOVA necessary?

ANOVA was necessary because it allows the comparison of multiple treatment groups simultaneously. It helps determine whether the observed differences in nickel removal among the dosage groups are statistically significant rather than due to chance.

Why not use multiple t-tests?

Using multiple t-tests would increase the likelihood of committing a Type I error, which is the false identification of a significant difference. ANOVA provides a more reliable method for comparing several groups at the same time

Why is adsorption capacity important?

Adsorption capacity is important because it measures how much nickel can be adsorbed per gram of adsorbent. This helps evaluate the efficiency of the adsorbent itself rather than just the overall removal percentage

Is your adsorbent truly sustainable?

Yes, our adsorbent is considered sustainable because it utilizes an abundant agricultural waste material that would otherwise be discarded. By repurposing banana pseudostem for water treatment, the study supports resource efficiency and waste reduction.

What is the biggest limitation of your study?

The biggest limitation of our study is that it was conducted using laboratory-prepared nickel solutions rather than actual wastewater. Real wastewater contains multiple contaminants that may influence adsorption performance and should be investigated in future research

What happens to the adsorbent after it captures nickel?

After adsorption, the nickel remains attached to the surface of the banana pseudostem. Therefore, the spent adsorbent should be managed responsibly through appropriate disposal or future regeneration methods to prevent secondary contamination.

How does your study contribute to sustainability?

Our study contributes to sustainability by transforming agricultural waste into a value-added environmental remediation material. This approach addresses both water pollution and waste management while supporting circular economy principles.

What is the most important contribution of your study?

The most important contribution of our study is demonstrating that banana pseudostem, an abundant agricultural waste material, has the potential to function as a biosorbent for nickel remediation, thereby providing a sustainable approach to addressing both water pollution and agricultural waste utilization.

Why should your study win the research congress?

Our study addresses two environmental challenges simultaneously: nickel contamination in water and the underutilization of agricultural waste. By applying scientific principles and sustainability concepts, we developed a practical and environmentally responsible approach that has potential relevance for communities seeking affordable water treatment solutions.

Memorize this "golden answer":

"Our study is significant because it transforms an agricultural waste product into a potential water treatment material, demonstrating how environmental pollution and waste management can be addressed through a single sustainable solution.”