LAUTECH Journal of Civil and Environmental Studies
Volume XVI, Issue I; March, 2026
DOI: 10.36108/laujoces/6202.61.0170

Evaluation of the Remediation Potential of Banana Peduncle (*Musa Acuminata Colla*) for Heavy Metal Removal from Galvanized Industrial Wastewater

[1*] Oyekanmi S. E., Coker A. O., and Achi C. G.

[1] Department of Civil Engineering (Water Resources & Environmental), University of Ibadan, Ibadan, Oyo State, Nigeria.

[*] Corresponding Author E-mail: **seunezekiel26@gmail.com** Tel: 080xxxxxxxx

Abstract

A successful construction project has many important components, one of which is labour. Many The discharge of heavy metals from galvanized industrial processes into water bodies presents a significant environmental hazard due to their toxicity, persistence, and bioaccumulation potential. Despite the availability of various physicochemical techniques for industrial wastewater treatment, many small to large-scale industries struggle with the high operational costs and technical complexities involved. This research work aims to evaluate the remediation potential of Banana Peduncle, identify optimal conditions for biosorption, and analyze the potential mechanisms in the adsorption process. A quantitative experimental research design was adopted to evaluate the biosorption capacity of banana Peduncle. The study involved: Collection and preparation of biosorbent (banana Peduncle), collection and analysis of galvanized industrial wastewater, batch adsorption experiments, characterization of raw adsorbents (Banana Peduncle) and analysis of metal concentrations after treatment. The raw banana Peduncle (BP) was analyzed and compared for their adsorption capacities. The effluents of the industrial wastewater samples from Prism Steel Rolling Mill, Osogbo Road, Ikirun Ifelodun Local Government Area, Osun State, Nigeria were collected and examined under the Atomic Absorption Spectrophotometry (AAS) analysis to determine the initial concentration of the heavy metals present. The adsorbent sample was examined under FTIR and SEM machine to measure the morphological surface for the adsorption process. The variables which influence the process of adsorption were the dosage of the adsorbent, contact time and the rate of agitation of the wastewater treatment. The initial concentration of heavy metals present in industrial galvanize wastewater sample, shows the presence of Zinc(70%), Manganese(0%), Lead(0%), Copper(2%), Iron(26%), Chromium(1%), and Cadmium(0%), with Zinc has the highest concentration, lead has the lowest concentration and cadmium was not detected in the samples. The balance of the adsorption process was related to the initial ions concentration of the metal, dosage of adsorbent, contact time, and the rotating speed. Based on the laboratory scale batch adsorption experiments conducted, the Banana peduncle demonstrated a high remediation potential or biosorption efficiency at raw state at the following optimal conditions; 0.2g, 100min and 100rpm for adsorbent dosage, contact time and rotating speed respectively with over 90% removal which aligned with Muthusamy et al. (2024). Further study should be carried out on carbonization and activation of Banana Peduncle as adsorbent.

Keywords: Banana Peduncle, biosorption, galvanized wastewater, heavy metals, adsorption isotherms, sustainable treatment.

Introduction

The rapid industrialization of the modern world has significantly contributed to economic development, but it has also introduced severe environmental challenges. Among the most pressing issues is the contamination of water bodies by industrial wastewater, particularly from the galvanizing industry. Galvanization involves the coating of steel or iron with a protective layer of zinc to stop rusting, and the resultant products of this procedure are effluents that are rich in heavy metals such as iron (Fe), zinc (Zn), lead (Pb), chromium (Cr), and cadmium (Cd) (Nurchi & Villaescusa, 2012). These toxic metals are not biodegradable, and they may continue existing in the environment, bioaccumulating in living organisms and causing harmful effects to both ecosystems and human health. (*Aamna et al. 2021*).

Conventional treatment techniques of heavy metal removal, including chemical precipitation, ion exchange, and membrane filtration, are costly, energy-consuming, and produce secondary waste (Fu & Wang, 2011). Consequently, the interest in is increasing exploring eco-friendly, cost-effective, and sustainable alternatives for wastewater treatment. Biosorption, which utilizes natural materials to adsorb contaminants, has emerged as a promising method in this regard. Despite the availability of various physicochemical techniques for industrial wastewater treatment, many small to large-scale industries struggle with the high operational costs and technical complexities involved. This often leads to the immediate release of un-treated. or half-treated effluent in water, exacerbating environmental pollution. The search for low-cost, effective adsorbents that can be sourced from agricultural waste has become an urgent necessity. In this context, banana Peduncle—a widely available agricultural byproduct in many tropical countries—offers a viable solution due to its rich lignocellulosic composition and inherent heavy metal binding functional groups. (Hegazi, 2013).

The management of industrial wastewater, particularly that originating from galvanizing operations, presents a significant environmental challenge due to the presence of heavy metals. Galvanizing is the electro-chemical process by which one metal is coated with another. It is called galvanization because this process was developed from the work of Luigi Galvani, who discovered in his experiments that if metal is placed into contact with the severed leg of a frog, the leg contracts as if it were connected to a live body. Through subsequent experiments, he discovered that the frog-leg had a different reaction depending on the metal, therefore concluding that each metal has a different electrical charge, depending on its type. (Ojoawo et al. 2019). The coating of steel or iron with zinc to provide protection is called galvanizing, often using hot-dip or electroplating techniques. These processes generate wastewater containing not only zinc but also other heavy metals like lead (Pb), cadmium (Cd), nickel (Ni) and chromium (Cr) due to corrosion inhibitors, degreasing agents, and acid cleaning (Ramakrishnaiah & Prathima, 2020). Heavy metals are toxic, persistent in the environment, and non-biodegradable. Their bioaccumulation in organisms can disrupt biological systems, even at low concentrations *Tchounwou et al.*, 2012. Some specific impacts include:-
Zinc (Zn), while essential in small amounts, excessive zinc causes nausea, vomiting, and immune dysfunction. Lead (Pb) is a powerful neurotoxin with developmental and cardiovascular disorders of children and adults. Cadmium (Cd), damages kidneys, demineralizes bones and is a human carcinogen. Chromium (Cr), particularly hexavalent chromium (Cr^{6+}), is mutagenic and carcinogenic. The long-term discharge of such metals without remediation severely degrades water quality, affecting agriculture, fisheries, and public health.

Banana Peduncles are an agricultural byproduct rich in cellulose, hemicellulose, and lignin. Such biopolymers have functional groups that can react with heavy metals through ion exchange, complexation and physical adsorption reaction. (Hegazi, 2013). Benefits of using Banana Peduncle: Abundant and renewable, especially in tropical regions or countries, biodegradable and eco-friendly, minimal or no pretreatment required, high water holding and swelling capacity. Several studies have reported the successful use of banana Peduncle in removing heavy metals like lead and cadmium from aqueous solutions (Akinola et al., 2020), though few have specifically examined their use in galvanized industrial wastewater. Lignocellulosic materials like banana Peduncle adsorb metals through: Ion exchange: Metal cations replace naturally bound cations (e.g., Na^+, Ca^{2+}). Complexation: Functional groups (–OH, –COOH) form coordinate bonds with metal ions. Electrostatic attraction: Interaction between negatively charged biosorbent surface and cationic metals. Micro-porous entrapment: Physical diffusion and trapping of metal ions in porous structures. *Muthusamy et al*. (2024) used banana peduncle reported removal efficiency of 94% for Pb from Pb (lead) solution under the following conditions, pH 5, contact time 120mins, dosage 3g/L and agitation rates of 200 revolution per min (RPM). *Aamna et al.* (2021) used banana peels (biomass) reported 97% removal of lead in aqueous solution at pH 5, 120mins contact time. *Rabiatul et al*. (2019) modified banana peels adsorbent and reported Pb and Fe ions removal efficiency 100 and 64% respectively. Bello & Ahmad (2011) highlighted the use of acid-modified banana peduncle for the removal of Cr (vi), achieving high adsorption capacity. While many researchers have explored biosorption using agricultural wastes, this research/paper specifically focused on banana Peduncle for the treatment of the industrial galvanizing wastewater sample because there is limited research works in this area. Most available studies use synthetic solutions, which may not represent real industrial conditions. Moreover, the influence of key operational parameters (pH, contact time, dosage) and the comparative performance of raw vs. modified banana Peduncle remains inadequately studied. This study focuses on the application of banana Peduncle for the remediation of galvanized industrial wastewater. The study is limited to batch adsorption experiments conducted under laboratory conditions. While results from such experiments offer valuable insights, field-scale applications may involve additional variables not considered in this study. Furthermore, the research is confined to specific heavy metals commonly found in galvanizing effluent and may not address other types of industrial pollutants.

Materials and Method

Collection of Adsorbent Materials and Preparations: The Adsorbent materials for this study was obtained locally from popular Owode – Ede market, along Osogbo/Gbongan Road, Ede - South Local Government Area, Osun State. The freshly collected Banana peduncle was washed with de-ionized water to remove adherent impurities and contaminants. The adsorbent material was sundried for 2 days and then Oven-dried for 30 minutes at 100^{o}C and grinded in a local mill. The fine granular materials was then stored in a corked sterilized 60c1 plastic container.

Collection of Industrial wastewater effluents: The preliminary experiment for this research was conducted using industrial wastewater samples collected from Prism Steel Rolling Mill, located along Osogbo Road, Ikirun, in Ifelodun Local Government Area, Osun State, Nigeria. The study employed banana peduncle as the treatment material. Wastewater samples were obtained from the factory's wastewater pool and transferred into a clean 5-litre plastic container, which was tightly corked. The samples were then transported to the laboratory for various analyses to determine the level of contamination.

Adsorption Batch Experiment: The absorbent study was carried out with 50ml of industrial wastewater sample poured into 100ml conical flask and 0.2g of prepared absorbent added, placed on J .P Selecta orbital shaker (Model No: 3000974 at 150 revolutions per minute (rpm) at room temperature for 60minutes. The suspension will be filtered with Dr. Watts's filter paper 12.50m (100 circles) and the filtrate subjected to AAS analysis; Ojoawo et al., (2019). The batch experiments with One Factor at A Time (OFAT) were conducted on the wastewater samples varying the factors of adsorbent dosage, contact time and rotating speed of rotary incubator.

Absorbent Dosage: This study was done with varying dosages of 0.2, 0.4, 0.6, 0.8, and 1.0g into 50m1 samples respectively and agitated at 150 rpm for 60mins and the suspension will be filtered with Dr. Watt's filter paper and the filtrate analyzed by AAS.

Contact Time: This was performed as 0.2g of the two adsorbents that were added to different conical flask containing 50ml of industrial wastewater, the flask was closed and placed in a rotary shaker and agitated at 150rpm for each of the different contact times chosen as 20, 40, 60, 80, 100 and 120 minutes. The content of each flask was filtered and analyzed by AAS after each agitation time.

Agitation or Rotating Speed: 0.2g of each adsorbent was measured into 50ml of the sample and subjected to four (4) agitation rpm starting with 50, 100, 150, and 200 at an interval of one (1) hour each. Each of the sampled was then filtered. The filtrate from each batch was subjected to AAS analysis while the residue was packed and labeled.

Atomic Absorption Spectrophotometry (AAS) analysis: The concentration of the untreated wastewater was determined through the analysis of the Atomic Absorption Spectrophotometry (AAS). The solution is the atomic absorption spectrophotometer (AAS) model number of PG6990. The AAS comprises of three

(3) primary components including the computer, the compressor and the main machine. The compressor on the main machine picked up the digested wastewater and sent signal to the computer. The quantity of the absorbed metals was measured by adjusting the wavelengths of the metals to be studied and then the monochromator measures them and the flame applied in the analysis is the air-acetylene flame. The flame that is created in air acetylene is approximately 23000C. Facts put into use by the AAS technique include the ability of neutral or ground state atoms of element to absorb electromagnetic radiation in a series of very narrow but sharply defined wavelengths.

Characterization of Adsorbent Material (Banana Penduncle)

Fourier Transform Infrared Spectroscopy (FTIR): The surface functional groups of Banana peduncle was determined by fourier Transform Infrared Spectroscopy (FTIR). FTIR was carried out using Infrared Spectrophotometer model: BUCK M530 series. Infrared spectroscopy is a powerful tool for identifying the presences of functionalities such as Hydroxyl, Carbonyl, alkane, aromatic compounds, amino compounds etc. The vibrational spectrum of a molecule is considered to be a unique physical property and is characteristics of the molecule. The most useful region of the infrared radiation extends from above 2.5 to 16 microns (1 micron = 1 micrometer = 10^{-6} meter).

SEM (Scanning Electron Microscopy): Scanning Electron Microscopy (SEM) is used very effectively in the microanalysis and failure analysis of solid inorganic materials. Electron microscopy is performed at high magnifications, generates high resolution images and precisely measures very small features and objects. The SEM equipment includes a variable pressure system capable of holding wet and or non-conductive samples with minimal preparation. The large sample chamber allows for examination of samples up to 200mm in diameter and 80mm in height. High resolution images are produced during SEM analysis at magnifications from 5 to 300,000x.

Results and Discussion

Table 1 shown the initial concentration of heavy metals present in galvanize wastewater sample, shows the presence of Zinc, Manganese, Lead, Copper, Iron, Chromium, and Cadmium. The table shows that Zinc is dominant i.e, has the highest concentration while the presence of the Lead is at the minimum concentration, whereas cadmium was not found in the wastewater at all.

Table 1: Initial concentration of heavy metals in the industrial Effluents before Batch experiment compared with Standards and quality Guidelines.

Metals	WHO Standards	SON Standard	Present Study
	MPL	MPL	mg/l
Zinc (Zn)	5.00mg/l	3.0mg/l	30.459
Manganese (Mn)	0.50mg/l	0.20mg/l	0.195
Lead (Pb)	0.015mg/l	0.01mg/l	0.076
Copper (Cu)	1.00mg/l	1.00mg/l	0.798
Iron (Fe)	0.30mg/l	0.30mg/l	11.480
Chromium (Cr)	0.05mg/l	0.05mg/l	0.280
Cobalt (Co)	-	0.05mg/l	0.410
Cadmium (Cd)	0.005mg/l	0.003mg/l	ND

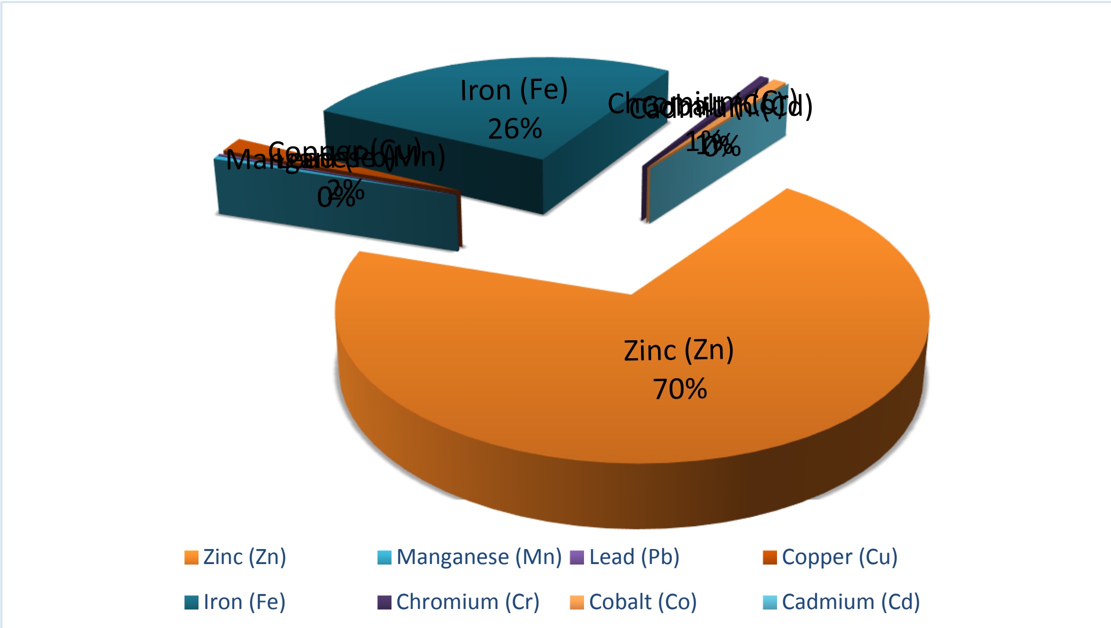


Fig. 1: Initial concentration of metals in percentage in the wastewater before experiment.

Results of batch Experiments:

Table 2 and Table 3 showed the adsorption capacity of the raw banana peduncle and percentage removal. It was observed that Lead, Manganese, Cobalt and Copper were totally adsorbed at 0.2, 0.4, 0.6, 0.8 and 1.0g respectively i.e. 100% of Lead was absorbed while Iron was absorbed at 81.64%**,** 87.56%, 95.03%, 95.03%, and 96.55% at 0.2, 0.4, 0.6, 0.8 and 1.0g respectively which implies that the adsorption increases with increase in the dosage of the adsorbent. This can be attributed to an increase in adsorptive surface are and the availability of more active adsorption sites on the adsorbent and it is a known fact that more adsorbent would help in faster and better adsorption of heavy metals.

Table 2: Result of Adsorbent Dosage

Dosage (g)	Co^{2+} (ppm)	Zn^{2+} (ppm)	Cu^{2+} (ppm)	Fe^{2+} (ppm)	Pb^{2+} (ppm)	Mn^{2+} (ppm)
0.2	ND	2.218	ND	0.271	ND	ND
0.4	ND	2.104	ND	0.631	ND	ND
0.6	ND	2.149	ND	0.634	ND	ND
0.8	ND	6.860	ND	1.745	ND	ND
1.0	ND	1.835	ND	1.615	ND	ND

Table 3: Percentage removal of Adsorbent Dosage

Dosage (g)	Co^{2+}	Zn^{2+}	Cu^{2+}	Fe^{2+}	Pb^{2+}	Mn^{2+}

	(% Removal)	(% Removal)	(% Removal)	(% Removal)	(% Removal)	(% Removal)
0.2	100	93.35	100	96.55	100	100
0.4	100	93.08	100	95.03	100	100
0.6	100	93.35	100	95.03	100	100
0.8	100	75.20	100	87.56	100	100
1.0	100	91.43	100	81.64	100	100

The pattern of treatment based on the effect of contact time of the adsorbent with wastewater using 0.2g (optimum dosage value used) of the Banana peduncle was shown on table 4, it was observed that copper, chromium, and manganese was efficiently absorbed from 20 – 100minutes of contact and lead was efficiently absorbed only at 60 minute and at 100 minutes with percentage removal of 100%, while others metals were also adsorbed at different percentage removal rate with significant absorption capacity.

Table 4: Effect of Contact time

Contact Time (Mins)	Co^{2+} (ppm)	Zn^{2+} (ppm)	Cu^{2+} (ppm)	Fe^{2+} (ppm)	Pb^{2+} (ppm)	Cr^{2+} (ppm)	Mn^{2+} (ppm)
20	-0.642	3.010	ND	0.374	0.196	ND	ND
40	0.347	2.876	ND	0.371	0.659	ND	ND
60	-0.156	1.514	ND	1.349	ND	ND	ND
80	-0.879	5.860	ND	1.994	0.911	ND	ND
100	-0.156	1.305	ND	0.863	ND	ND	ND

Table 5 shows that Copper ion Cu^{2+} and Chromium Cr^{2+} was absorbed totally at all rotating speed (50rpm – 200rpm), all other metals shows effective 100 percent absorption capacity at 100rpm, except Iron (Fe^{2+}) which has 98 percent absorption.

Table 5: Effect of Rotating Speed

Rotating Speed (rpm)	Co^{2+} (ppm)	Zn^{2+} (ppm)	Cu^{2+} (ppm)	Fe^{2+} (ppm)	Pb^{2+} (ppm)	Cr^{2+} (ppm)	Mn^{2+} (ppm)
50	-0.642	5.916	ND	1.077	0.659	ND	-2.322
100	ND	ND	ND	0.200	ND	ND	-2.808
150	-0.879	1.410	ND	0.466	0.659	ND	-1.847

200	-0.642	10.648	ND	0.728	0.420	ND	-0.710

The FTIR spectroscopy shown in Figure 2 shows the functional groups in the Banana peduncle sample. The transmittance peaks at 3355 and 3239cm^{-1} shows the intramolecular O-H bonds while the bands at 2832, 2801, 2707cm^{-1} shows the assymetric and symmetric C-H respectively. The free carbonyl group (C=O) was seen at 1781cm^{-1} while the C=C aromatic of the Banana peduncle sample was seen at 1558.1. The C-H bend vibrations were shown at 1407, 1268 and 1210cm^{-1} respectively. The out of plane bending vibrations for the carbon back bones were shown at 1007, 907 and 815cm^{-1}.

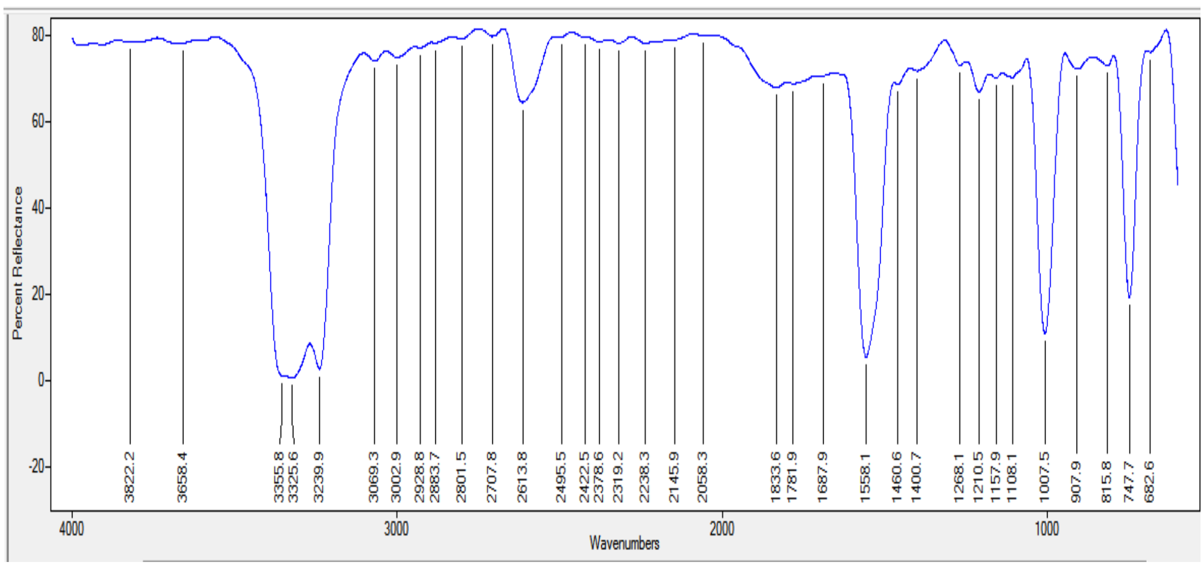
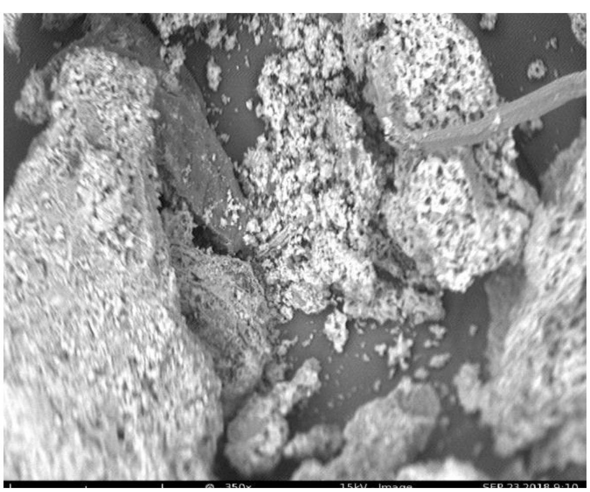


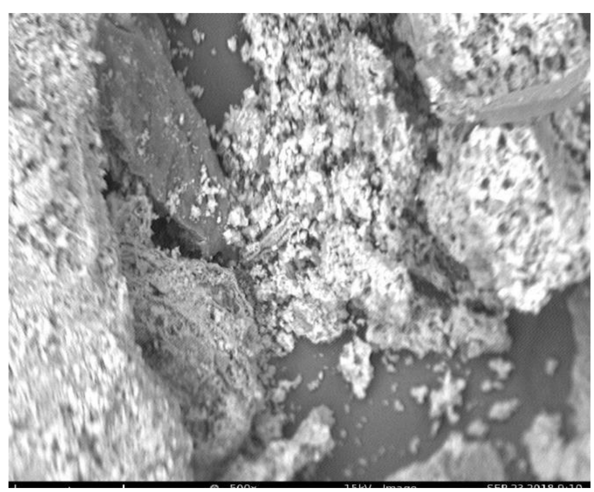
Figure 2: FTIR Result of Banana peduncle

In Figures 3a and b, the Scanning Electron Microscope images of the raw adsorbent before adsorption batch experiment (a) at 350x magnification and (b) at 500x magnification. It can be seen that there are pore spaces in the raw adsorbent before sorption experiment which would enable the adsorbent to fill up the pore spaces with the heavy metals ions during the adsorption process.

(a)



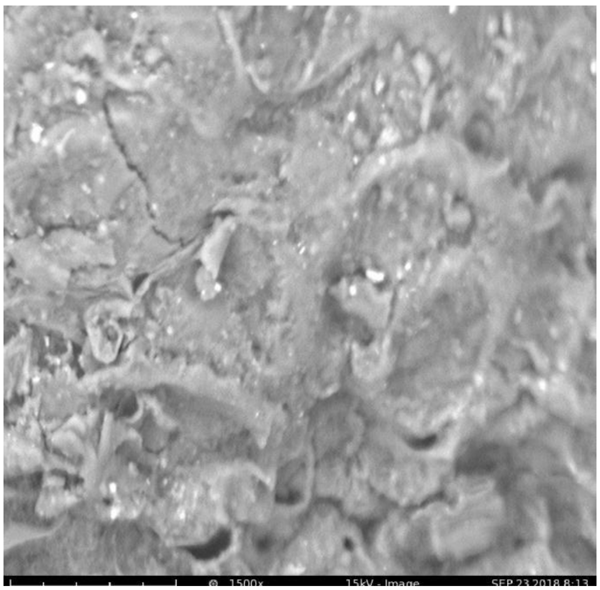
(b)



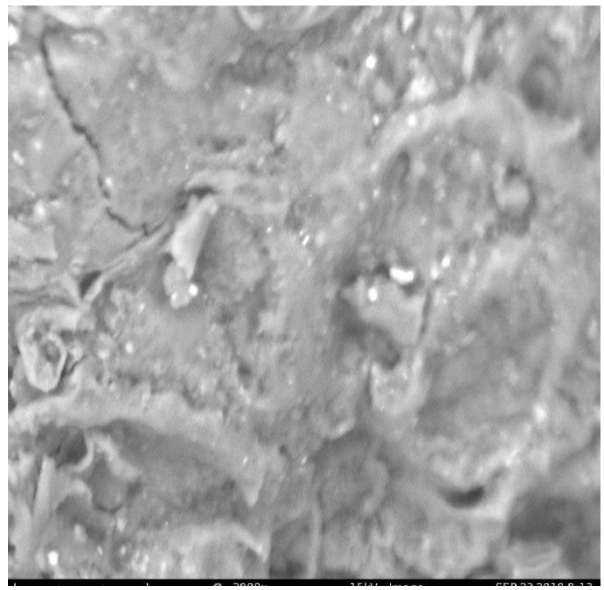
Figures 3a and b: SEM Images of raw Banana Peduncle before experiments at (a) 350x, (b) 500x magnification.

In Figures 4a and b, the Scanning Electron Microscope images of the loaded adsorbent after adsorption batch experiment at different high magnification of 1500x and 2000x to show that the adsorbent pores have been filled up with metals ions during sorption batch experiment process. Furthermore, according to the SEM analysis the sorbed heavy metal ions are uniformly distributed on the surface and interior pores of the Banana peduncle (BP) adsorbent and they are characterized by a filled up structure in line with *Muthusamy et al.* (2024)

(a)



(b)



Figures 4a and b: SEM Images of loaded Banana Peduncle after experiments at (a) 1500x, (b) 2000x magnification.

Conclusion

This research works presents the results of the adsorption study of Banana Peduncle (Musa Acuminata Colla) for the remediation of galvanized industrial wastewater containing heavy metals such as zinc (Zn^{2+}), Iron (Fe^{2+}), lead (Pb^{2+}), and chromium (Cr^{6+}) etc., using locally sourced agricultural, low cost, eco – friendly, sustainable, and abundantly available materials as an effective biosorbent for removal of heavy metals ions in aqueous solution.

The following conclusions have been drawn:

i. Banana peduncle demonstrated a high remediation potential or biosorption efficiency at raw state,
ii. Percentage removal rates of the Banana Peduncle (BP) was very high (average of 90% removal) which aligned with P. Muthusamy et al. (2024).
iii. The BP remediation capacity (adsorption performance) was influenced by key parameters such as absorbent dosage, contact time and agitation or rotation speed and initial concentration of heavy metals in the sample,
iv. Banana Peduncle reported removal efficiency of above 90% removal for heavy metals from galvanized industrial wastewater with raw sample under the following conditions, contact time 60mins, absorbent dosage 2g/L and agitation rates of 100 revolution per min (RPM).

References

Aamna, A., Razyia N., Shamsa B., Umer R., Muhammad A. H., Nazish J., Zeeshan A., Zubair A., Muhammad A. and Maleeha N. 2024. Efficient Adsorption of Lead Ions from Synthetic Wastewater Using Agrowaste-Based Mixed Biomass (Potato Peels and Banana Peels *Water 2021*, 13: 3344.

Abdel Ghani N. T., El-Chaghaby, G. A., & Fadel, M. 2016. Biosorption for metal ions removal from aqueous solutions A review of recent studies. *International Journal of Environmental Science and Technology*. 13(9): 2129–2148.

Ahmad, A. A., Hameed, B. H., & Aziz, N. 2007. Adsorption of direct dye on palm ash: Kinetic and equilibrium modeling. *Journal of Hazardous Materials*, 141(1): 70–76.

Akinola, M. O., Eze, S. I., & Ezeh, I. O. 2020. Comparative adsorption of Pb(II) and Cd(II) ions from aqueous solutions using banana stalk and cocoa pod husk. *Environmental Technology & Innovation*, 18: 100778.

Bailey, S. E., Olin, T. J., Bricka, R. M., & Adrian, D. D. 1999. A review of potentially low-cost sorbents for heavy metals. Water Research, 33(11): 2469–2479. https://doi.org/10.1016/S0043-1354(98)00475-8

Deacero 2017, Retrieved March 6, 2025, 09:00:45pm from http://www.deacerocontinueeducation.com

Foo, K. Y., & Hameed, B. H. 2010. Insights into the modeling of adsorption isotherm systems. *Chemical Engineering Journal*, 156(1): 2–10. https://doi.org/10.1016/j.cej.2009.09.013

Fourex E., Roux J.C., 1992; Heavy metal biosorption by fungal mycelia by – products: Mechanism and influence of pH; *Applied Microbial Biotechnol*, 37. 399 – 403.

Fu, F., & Wang, Q. 2011. Removal of heavy metal ions from wastewaters: A review. *Journal of Environmental Management*, 92(3). 407–418.

Garg, U. K., Kaur, M. P., Garg, V. K., & Sud, D. (2008). Removal of hexavalent chromium from aqueous solution by agricultural waste biomass. *Journal of Hazardous Materials*, 154; 1149–1157.

Hegazi, H.A. (2013). Removal of heavy metals from wastewater using agricultural and industrial wastes as adsorbents: A review. *HBRC Journal*, 9(3). 276–282.

Kołodyn´ska D., Krukowska J., Thomas P. 2017, "Comparison of sorption and desorption studies of heavy metal ions from biochar and commercial active carbon". *Chemical Engineering Journal* 307: 353–363

Kurniawan, T. A., Chan, G. Y. S., Lo, W.-H., & Babel, S. 2006. Physico–chemical treatment techniques for wastewater laden with heavy metals. *Chemical Engineering Journal*, 118(1–2). 83–98. https://doi.org/10.1016/j.cej.2006.01.015

Majumdar J., Baruah B. K., and Dutta K. 2004. Sources and Characteristics of Galvanizing Industry Effluent, *Journal of Industrial Pollution Control* Vol. 5: 87 -97.

Mohammad, A., & Shafqat, M. N. 2019. Biosorption of heavy metals using banana peel powder. *Environmental Technology & Innovation journal*, Vol. 13: 264–276.

Muthusamy P., Murugan S., Sanjeeb K. M., Bishwambhar M.,Yugal K. M., Hemen S., and Mahesh N., 2024. Utilizing Banana Peduncle as an Affordable Bio-Adsorbent Removal of Lead Ions From Water And Industrial Effluents. *Sustainable Chemistry for the Environment* 7: 100150.

Nurchi, V.M., and Villaescusa, I. 2012 Agricultural biomasses as sorbents of some trace metals. *Coordination Chemistry Reviews*, 252: 1178 – 1188.

Ojoawo S.O., Oyekanmi S. E., and Pushparaj N., Adsorption and Desorption of Fe^{2+} Using Sugarcane Bagasse Activated Carbon in Remediating Metal Galvanizing Industrial wastewater. *Think India Journal*, Vol. 22. Issue: 14 – December- 2019, ISSN: 0971-1260

Ojoawo S.O., Adegbola A.A., O.S. Olaniyan, R.A. Olaoye, Oluremi J.R., Ajamu S.O., Ademola A.A. & Ademola I.A. 2018, Performance evaluation of Azadirachta Indica (Neem Tree) bark in the remediation of Pb^{4+} and Cr^{3+} from galvanizing industrial wastewater Advances In Multidisciplinary and Scientific Research (AIMSR), *a multidisciplinary and interdisciplinary journal*, Vol. 4: No. 2 June 2018.\6

Park, D., Yun, Y. S., & Park, J. M. 2005. Use of dead fungal biomass for the detoxification of hexavalent chromium: Screening and kinetics. *Process Biochemistry journal*, 4: 2559–2565.

Rabiatul M. M., Norazlina H., Suhaila A., Nabihah A., Amri M., MohdAbu A. D., KahaFakrul A. M., 2019. Adsorption of Heavy Metals on Banana Peel Bioadsorbent. 4th International Conference on Engineering Technology (ICET 2019). *Journal of Physics,* Conference Series 1532: (2020) 012014.

Sunil K., and Hemant P. R., Effect of Conventional and Non-Conventional (Eco-Friendly) Fluxes on Hot Dip Galvanizing - a Review, *International Journal of Advance Engineering and Research Development Vol: 1, Issue 1.*