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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
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ISETC 2025 Proceedings Editors

DEVELOPMENT OF BIOCHAR FROM POST-PHYTOREMEDIATION OF *Eichhornia crassipes*

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Abstract: This study aimed to assess the chromium-removal capacity of *Eichhornia crassipes* and to characterize the biochar derived from its biomass after phytoremediation. *E. crassipes* plants were exposed for 14 days to FSSA lake water spiked with chromium at concentrations of 3 mg/L and 5 mg/L to simulate heavy-metal–contaminated wastewater. Plant health was monitored via visual symptoms (leaf chlorosis and wilting), while removal efficiency (%) and bioconcentration factor (BCF) were determined by measuring chromium concentrations in the water and in harvested tissues. Following phytoremediation, biomass was pyrolyzed at 300 °C for 30 minutes. The results showed that at 5 mg/L chromium, plants displayed toxicity, yellowing leaves and wilting whereas no adverse symptoms occurred at 3 mg/L. Under the lower concentration (3 mg/L), *E. crassipes* achieved 96.58% removal efficiency and a BCF of 338.54, confirming strong phytoaccumulation ability. Pyrolysis converted approximately 50% of biomass into biochar by mass. The chromium concentration in biochar (52.26 ug/g) exceeded that in residual plant tissue (37.24 ug/g), indicating effective immobilization of accumulated metal. Moreover, surface area, pore structure, and functional-group analyses revealed that biochar derived from phytoremediated biomass closely matched the properties of control biochar, demonstrating that metal uptake did not adversely affect material quality. These findings highlight *E. crassipes* as a viable agent for chromium phytoremediation and demonstrate that its post-treatment biomass can be transformed into a stable, metal-rich biochar. Future work should optimize pyrolysis parameters to maximize metal retention, evaluate the biochar's adsorption performance for other pollutants, investigate its long-term stability and leaching behavior under field conditions for sustainable wastewater management.

Keywords: *Phytoremediation, E. crassipes, chromium, biochar, pyrolysis*

INTRODUCTION

Water pollution, particularly from heavy metals and persistent organic pollutants, has emerged as one of the most pressing environmental issues in the 21st century. The rapid pace of industrialization, urban expansion, and unsustainable agricultural practices has led to the continuous release of toxic contaminants into aquatic systems. These pollutants not only disrupt aquatic ecosystems but also pose severe risks to human health through bioaccumulation and biomagnification in the food chain (Bashir et al., 2020). Conventional remediation techniques such as chemical precipitation, ion exchange, and membrane filtration, although effective, are often associated with high operational costs, energy demands, and secondary pollution risks. Phytoremediation involves the use of green plants to extract, stabilize, degrade, or volatilize contaminants from soil or water. Among various aquatic macrophytes, *Eichhornia crassipes* (water hyacinth) is widely recognized for its phytoremediation potential (Zahari et al., 2023). Its rapid growth, large biomass production, and extensive root system enable efficient uptake of a wide range of pollutants, including heavy metals like chromium, lead, cadmium, and arsenic. Despite its effectiveness in pollutant removal, the safe disposal of contaminated *E. crassipes* biomass post-phytoremediation poses a significant challenge. Improper handling may lead to the reintroduction of sequestered contaminants into the environment (Liu et al., 2024). An emerging solution is the conversion of this post-remediation biomass into biochar, a stable, carbon-rich material produced via pyrolysis (Amalina et al., 2022). Biochar has been widely explored for its use in soil amendment, pollutant adsorption, and carbon sequestration. Its high surface area, porosity, and surface functional groups make it suitable for environmental applications. Importantly, converting *E. crassipes* into biochar presents a sustainable pathway that mitigates disposal risks and produces a value-added product. Therefore, this study aims to produce biochar from post-phytoremediation *E. crassipes* and to assess its potential for environmental applications. The research specifically focuses on evaluating the pyrolysis behavior of metal-enriched biomass, characterizing the physicochemical and metal-retention properties of the resulting biochar, and determining its suitability for uses such as heavy metal adsorption and soil immobilization.

MATERIALS AND METHODS

Plant Collection and Experimental Setup

Mature *E. crassipes* specimens were collected from a local aquatic environment and acclimatized in clean water under ambient conditions for one week prior to the experiment. The phytoremediation experiment was conducted using lake water obtained from FSSA, which was artificially spiked with chromium (Cr) at two concentrations: 3 mg/L and 5 mg/L. The plants were exposed to the treated water in separate containers for a duration of 14 days.

Phytoremediation Performance Assessment

Throughout the exposure period, plant health was monitored visually, noting signs of metal stress such as chlorosis and wilting. Water samples were collected at the start and end of the experiment to determine residual chromium concentrations using atomic absorption spectroscopy (AAS) (Reichman, 2002). The chromium removal efficiency (%) was calculated based on initial and final concentrations. After 14 days, plant tissues (roots and shoots) were harvested, washed, dried, and digested using nitric acid for total chromium analysis. The bioconcentration factor (BCF) was calculated as the ratio of chromium concentration in plant tissue to that in the water.

Biochar Production

Post-phytoremediation biomass was air-dried and subjected to pyrolysis in a muffle furnace at 300 °C for 30 minutes under limited oxygen conditions (Amalina et al., 2022). The yield of biochar was recorded as the percentage mass of biochar relative to the initial dry biomass.

Biochar Characterization

Ultimate analysis was conducted to determine the elemental composition of the biochar. Scanning Electron Microscopy (SEM) was also performed on both the biomass and the resulting biochar to investigate surface morphology. For ultimate analysis, the contents of carbon (C), nitrogen (N), and hydrogen (H) were determined using a CNHS elemental analyzer through flash combustion at 1020 °C, following the method by Ma et al. (2016). The pH of the biochar was measured using a 1:5 (w/v) biochar-to-water suspension, shaken for 1.5 hours using a reciprocal shaker, followed by a 1-hour equilibration period. Electrical conductivity (EC) was determined from the same extract, as described by Singh et al. (2017)

RESULTS AND DISCUSSION

Removal Efficiency of Chromium by *E. crassipes*

As shown in Figure 1, the initial chromium concentration in Treatment E1 was 5.31 mg/L, which decreased substantially to 0.57 mg/L by the end of the exposure period. In Treatment E2, the chromium concentration declined from 3.13 mg/L to 0.11 mg/L. These reductions correspond to removal efficiencies of 89.29% and 96.58% for E1 and E2, respectively, indicating a strong potential of *E. crassipes* for chromium remediation in aquatic systems. The high removal performance observed may be attributed to the plant's morphological and physiological traits, including its dense fibrous root system, broad leaf surface area, and rapid growth rate (Poorter et al., 2012) Previous studies by Singh and Sinha (2011) reported that *E. crassipes* achieved nearly 90% removal of chromium at an initial concentration of 5 mg/L within two days. Similarly, Monroy-Licht et al. (2024) documented a 70% removal efficiency for metals such as copper, aluminum, lead, mercury, cadmium, and metalloids such as arsenic with notable improvements in water quality. The current study is consistent with these reports, further demonstrating the species' effectiveness under varying concentration levels. Moreover, the data suggest that removal efficiency may increase with extended exposure time. It is anticipated that prolonging the treatment duration beyond the current experimental period, particularly in E1, could result in even higher chromium removal efficiencies.

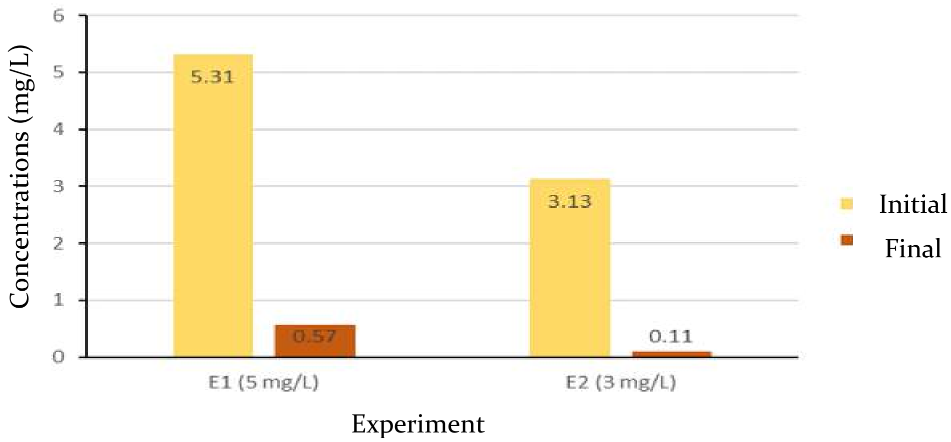

Figure 1. Initial and final concentration of Cr in the simulated wastewater

Accumulation of Heavy Metal Chromium (Cr) in the Plant Tissues of *E. crassipes*

Figure 2 presents the distribution of chromium measured in *E. crassipes* tissues following phytoremediation at different concentration levels. The chromium content in plants exposed to the lower concentration treatment (E2) was recorded at 37.24 µg/g, whereas those from the higher concentration treatment (E1) exhibited 26.39 µg/g. The higher accumulation observed in E2 may be attributed to a greater proportion of root tissue included during sample preparation, as roots are known to be primary sites for metal uptake and sequestration. In comparison, control samples exhibited a substantially lower chromium concentration of 1.55 µg/g, indicating that the native habitat of the collected *E. crassipes* was not subject to elevated chromium exposure. These results suggest a strong metal uptake capacity of *E. crassipes* under controlled contamination scenarios. The calculated bioconcentration factors (BCFs) were 46.21 for E1 and 338.54 for E2, both exceeding the threshold value of 1, which denotes effective phytoaccumulation. These values are consistent with findings reported by Taufik Taufikurahman et al. (2017) and Saha et al. (2016) who also identified *E. crassipes* as an efficient accumulator of chromium in aquatic environments. According to the classification by Brooks (1994), a plant is considered a hyperaccumulator if it contains more than 1 µg/g (dry weight) of chromium, cobalt, copper, nickel, or lead, or more than 10 µg/g of iron, manganese, or zinc in its tissues. Based on the data obtained in this study, *E. crassipes* meets the criteria for chromium hyperaccumulation thus supporting its potential application in phytoremediation of heavy metal–contaminated water bodies.

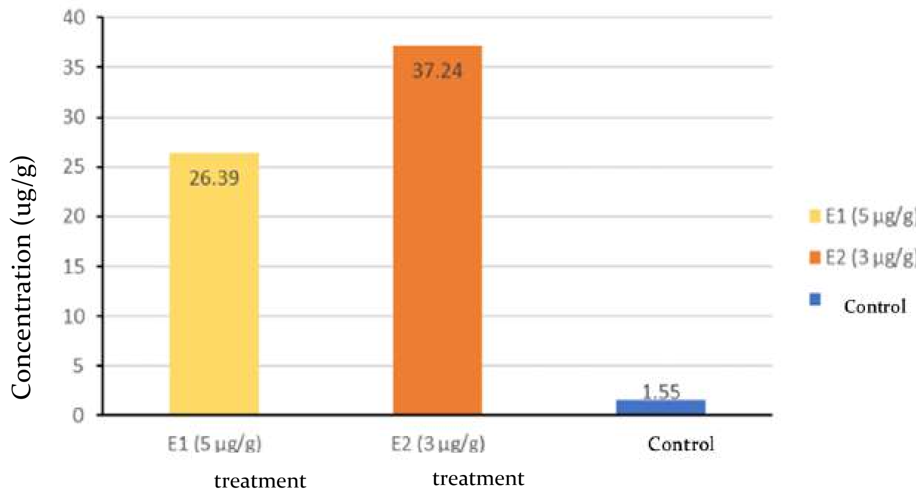

Figure 2. Chromium concentration in plant tissues under different treatment conditions

Biochar Production Following Phytoremediation

The physicochemical properties of *E. crassipes* biochar, including biochar yield percentage, pH, color, carbon (C), hydrogen (H), and nitrogen (N) content, as well as the concentration of chromium (Cr) in the biochar following phytoremediation, are presented in Table 1. The results showed that both E1 and E2 biochar samples appeared dark black and showed alkaline pH values of 7.15 and 7.80, respectively. Biochar yield was slightly higher in E1 (48.76%) than in E2 (47.51%). Elemental composition showed carbon, hydrogen, and nitrogen contents of 45.4%, 4.5%, and 2.1% for E1, and 46.2%, 4.2%, and 1.9% for E2. The C/N ratios were 21.61 and 24.31, respectively. Chromium concentrations in the biochar were 70.46 µg/g (E1) and 52.26 µg/g (E2), exceeding those found in plant tissues, indicating effective immobilization during pyrolysis. The differences are likely due to the decomposition of organic matter and entrapment of metals in the carbon matrix. Lower pyrolysis temperatures, such as 300 °C used here, are favorable for retaining heavy metals in biochar. SEM analysis (Figure 3) revealed structural changes after pyrolysis, with E1 showing a smoother surface and E2 a more porous morphology. Surface structure and porosity influence the adsorption potential of biochar. The lower pH and higher yield of E1 suggest better potential for chromium adsorption via electrostatic interaction. Overall, biochar from E1 demonstrated better chromium retention and yield, making it more suitable for environmental remediation applications.

Table 1. Physicochemical Properties of Biochar and Chromium Concentration After the Pyrolysis Process

Biochar	Color	pH	Yield (%)	C% (w/w)	H% (w/w)	N% (w/w)	Ratio H/C	Concentration of Cr (µg/g)
E1	Dark black	7.15	48.76	45.4	4.5	2.1	0.099	70.46
E2	Dark black	7.80	47.51	46.2	4.2	1.9	0.091	52.26

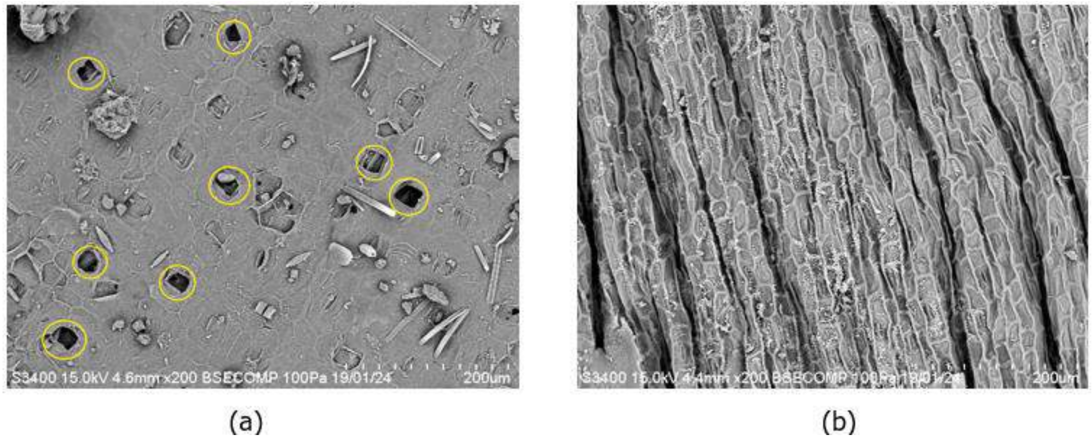

Figure 3. SEM Images of (a) Biomass and (b) Biochar of *E. crassipes*

CONCLUSIONS

The results of this study demonstrate that *E. crassipes* exhibits strong potential as a phytoremediation agent for chromium-contaminated water. The highest removal efficiency was observed in Experiment E2 (3 mg/L), achieving 96.58%. This suggests that lower chromium concentrations exert less physiological stress on the plant, promoting more effective uptake. A bioconcentration factor (BCF) greater than 1 further supports the plant's suitability for chromium phytoaccumulation. Notably, *E. crassipes* exposed to 3 mg/L chromium showed no visible toxic effects on plant morphology, indicating this concentration is optimal for safe and effective phytoremediation. Moreover, converting the harvested biomass into biochar proved effective for immobilizing accumulated chromium. Biochar offers a more stable and long-lasting matrix than raw biomass, reducing the risk of chromium re-release into the environment over time. These findings support the integration of phytoremediation and biochar production as a sustainable strategy for long-term heavy metal remediation

REFERENCES

Amalina, F., Razak, A. S. A., Krishnan, S., Sulaiman, H., Zularisam, A. W., & Nasrullah, M. (2022). Biochar production techniques utilizing biomass waste-derived materials and environmental applications – A review. *Journal of Hazardous Materials Advances*, *7*, 100134. https://doi.org/10.1016/J.HAZADV.2022.100134

Bashir, I., Lone, F. A., Bhat, R. A., Mir, S. A., Dar, Z. A., & Dar, S. A. (2020). Concerns and Threats of Contamination on Aquatic Ecosystems. *Bioremediation and Biotechnology*, 1. https://doi.org/10.1007/978-3-030-35691-0_1

Brooks, R. R. (1994). Plants that Hyperaccumulate Heavy Metals. *Plants and the Chemical Elements*, 87–105. https://doi.org/10.1002/9783527615919.CH4

Liu, N., Zhao, J., Du, J., Hou, C., Zhou, X., Chen, J., & Zhang, Y. (2024). Non-phytoremediation and phytoremediation technologies of integrated remediation for water and soil heavy metal pollution: A comprehensive review. *Science of The Total Environment*, *948*, 174237. https://doi.org/10.1016/J.SCITOTENV.2024.174237

Ma, X., Zhou, B., Budai, A., Jeng, A., Hao, X., Wei, D., Zhang, Y., & Rasse, D. (2016). Study of Biochar Properties by Scanning Electron Microscope – Energy Dispersive X-Ray Spectroscopy (SEM-EDX). *Communications in Soil Science and Plant Analysis*, *47*(5), 593–601. https://doi.org/10.1080/00103624.2016.1146742

Monroy-Licht, A., Carranza-Lopez, L., De la Parra-Guerra, A. C., & Acevedo-Barrios, R. (2024). Unlocking the potential of Eichhornia crassipes for wastewater treatment: phytoremediation of aquatic pollutants, a strategy for advancing Sustainable Development Goal-06 clean water. *Environmental Science and Pollution Research International*, *31*(31), 43561. https://doi.org/10.1007/S11356-024-33698-9

Poorter, H., Niklas, K. J., Reich, P. B., Oleksyn, J., Poot, P., & Mommer, L. (2012). Biomass allocation to leaves, stems and roots: meta-analyses of interspecific variation and environmental control. *New Phytologist*, *193*(1), 30–50. https://doi.org/10.1111/J.1469-8137.2011.03952.X

Reichman, S. M. A. (2002). The Response Of Plant To Metal Toxicity: A Review Of Focusing On Copper, Magnase And Zinc. *Australian Minerals and Energy Environment Foundation*, *January 2002*, 1–54. https://www.researchgate.net/publication/309374417_The_Responses_of_Plants_to_Metal_Toxicity_A_review_focusing_on_Copper_Manganese_and_Zinc

Saha, P., Shinde, O., & Sarkar, S. (2016). Phytoremediation of industrial mines wastewater using water hyacinth. *International Journal of Phytoremediation*, *19*(1), 87. https://doi.org/10.1080/15226514.2016.1216078

Singh, B., Shen, Q., Arbestain, M. C., Dolk, M. M., & Camps-Arbestain, M. (n.d.). *Chapter 3. Biochar pH, electrical conductivity and liming potential Biochar ageing effects on N and P dynamics:Mechanisms and controlling factors View project Soils in the globl agenda-ITPS-GSP?FAO View project 3 Biochar pH, electrical conductivity and liming potential*. Retrieved June 24, 2025, from https://www.researchgate.net/publication/319206365

Singh, G., & Sinha, A. (2011). Phytoremediation of chromium(VI)-laden waste by Eichhornia crassipes. *International Journal of Environmental Technology and Management*, *14*(1–4), 33–42. https://doi.org/10.1504/IJETM.2011.039256

Taufik Taufikurahman, Asih Suryati, Muhammad R. Kadar, & Nindya A. Wulansari. (2017, March). *(PDF) Phytoremediation of Chromium Polluted Water Using Water Hyacinth (Eichhornia crassipes (Mart.) Solms), Water Lettuce (Pistia stratiotes L.), and Water Hyssop (Bacopa monnieri L.) in a Simulated Constructed Wetland*. Proceeding Book The 7th Basic Science International Conference.

Zahari, N. Z., Julius, M., Cleophas, F. N., Adnan, F. A. F., Budin, K., & Tair, R. (2023). Phytoremediation Potential of Salvinia Molesta to Reduce Ni and Cd from Simulated Wastewater. *Green Energy and Technology*, 3–17. https://doi.org/10.1007/978-981-99-1695-5_1

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SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

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Setuju.

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