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Utilization of Water Hyacinth (*Eichhornia crassipes*) in compost production and its application for sustainable agriculture

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ABSTRACT

Water hyacinth (Eichhornia crassipes) is one of the most invasive aquatic weeds, causing serious environmental and economic impacts in water bodies. However, it has the potential to be composted as an organic fertilizer because of its high nutrient content. The purpose of this study was to make compost from water hyacinth and assess its suitability for use in agriculture. Water hyacinth biomass was harvested, mechanically chopped, mixed with carbon-rich bulking agents (rice straw, cow dung, ash, and soil), and composted for four months with periodic turning. Fertility assays were used to examine the germination%, relative root growth and elongation of shooting and rootingof the compost.The results indicated a seed germination index >80%, showing that the compost was non-toxic and safe for agricultural application. When compared to control soil, plant height and quality were enhanced by the compost application. According to the research, water hyacinth compost can serve as an inexpensive sustainable fertilizer that lessens reliance on chemical fertilizers and aids the environment by controlling invasive weeds.

Keywords: Water hyacinth (*Eichhornia crassipes*), compost, nitrogen, nutrients organic fertilizer, sustainable agriculture, soil improvement

INTRODUCTION

Water hyacinth is one of the world's most aggressive invasive aquatic plants, rapidly colonizing freshwater bodies and forming dense mats that disrupt ecological balance, impede navigation, reduce ecological oxygen, and harm fisheries and water management systems (Canning *et al.*, 2025; Gaurav *et al.*, 2020). The plant flourishes in nutrient-rich eutrophic environments, resulting in large biomass buildup and significant ecological management costs (Nandiyanto *et al.*, 2024). Paradoxically, the same characteristics that harm the environment—rapid growth, high cellulose content, and strong nutrient uptake capacity—make water hyacinth a promising biomass resource for valorization pathways, particularly composting and circular bioeconomy solutions. Composting allows water hyacinth biomass to be converted into a nutrient-rich organic amendment for agricultural use (Begum, 2021; Vincent-Akpu *et al.*, 2024). Composting biologically transforms organic materials, lowering phytotoxicity, stabilizing organic matter, and increasing nutrient availability, particularly nitrogen, phosphorus, and potassium (Serafini, 2025). When used correctly, water hyacinth compost increases soil structure, water retention, microbial activity, and crop output (Dushimeyesu *et al.*, 2024; Mazumder, 2021). Co-composting with bulking agents such cow dung, rice straw, sawdust, or biochar has also been shown to improve aeration, carbon-to-nitrogen balance, and decomposition efficiency (Serafini *et al.*, 2024).

Despite these advantages, safety concerns persist about the presence of heavy metals and environmental toxins acquired by water hyacinth during its life cycle, particularly in polluted water bodies (Patinha, 2025). Several authors have advocated pretreatment procedures, root system removal, controlled mixing ratios, and field application rates to assure environmental safety. According to life-cycle assessment research, incorporating water hyacinth compost into agricultural systems has the potential to significantly reduce synthetic fertilizer dependency, carbon footprint, and eutrophication impacts while also supporting community-scale circular economy strategies (Abba *et al.*, 2025).

Overall, existing research shows that composting water hyacinth provides an environmentally friendly waste-to-resource pathway that can address ecological

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management issues while also supporting sustainable agriculture and soil enhancement goals (Canning *et al.*, 2025; Serafini, 2025). However, more study is needed to standardize composting techniques, analyze long-term field impacts, measure soil-plant metal mobility, and develop regulatory frameworks for safe agricultural usage (Patinha *et al.*, 2025; Abba *et al.*, 2025). According to this need, the current investigation addresses the controlled composting of water hyacinth biomass utilizing widely available carbon-rich substrates such as rice straw, cow dung, ash, and soil. Throughout the decomposition process, the compost was observed and assessed for maturity, safety, and nutrient performance using germination bioassays and plant growth trials. The conclusions of this research are expected to give scientific basis for the conversion of an invasive weed into a valuable agricultural input, while simultaneously solving waste management difficulties and lowering the dependency on chemical fertilizers. Ultimately, this study contributes to promoting sustainable agriculture and circular biomass usage techniques by demonstrating the potential of water-hyacinth-based compost as an eco-friendly soil additive.

Phytochemical Profile of Eichhornia crassipes

Eichhornia crassipes (Fig. 1) is chemically relevant for environmental, agricultural, and medicinal purposes since recent phytochemical studies have shown that it contains a wide variety of bioactive chemicals. The presence of phenolics, flavonoids, tannins, alkaloids, saponins, terpenoids, glycosides, sterols, and organic acids in various plant parts has been confirmed by thorough LC–MS/MS and GC–MS analyses; leaves and flowers show the highest concentrations of secondary metabolites (Bakrim *et al.*, 2025).The plant's vast chemical complexity has been demonstrated by the discovery that methanolic extracts include up to 72 different chemical elements, such as stigmasterol, β-sitosterol, derivatives of caffeic acid, and flavonoid glycosides (Hasnat *et al.*, 2024). The functional roles of these compounds in free-radical scavenging processes are confirmed by recent studies that show considerable antioxidant activity connected with high total phenolic and flavonoid content (Deshlahre& Kulkarni, 2025; Shukla *et al.*, 2023). Furthermore, enhanced recovery of phenolics and flavonoids has been shown by extraction optimization utilizing AI-assisted modeling, underscoring the possibility of bioactive extraction on an industrial scale (Korkmaz *et al.*, 2025).Further evidence that these phytochemicals contribute to antimicrobial and antiproliferative activities, supporting possible therapeutic uses, comes from bioactivity assays, such as cytotoxic and antibacterial studies (Febriani *et al.*, 2024; Ahmed *et al.*, 2025). Many of these chemicals undergo microbial change and breakdown during composting, which lowers initial phytotoxicity and aids in humification processes. This is consistent with the high germination index found in this study. All things considered, E. crassipes' phytochemical richness explains both its ecological resilience and its growing significance as a biomass resource for applications in circular bioeconomy, green chemistry, and biofertilizer production.

Classification

Kingdom: Plantae

Phylum: Tracheophyta

Class: Liliopsida

Order: Commelinales

Family: Pontederiaceae

Genus: *Pontederia*

Species: *P. crassipes* (or *E. crassipes*)

Fig. 1: Water hyacinth plant and their classification

MATERIAL AND METHODS

Water hyacinth, Bulking Agent, animal manure (cow dung or other animal manure), rice straw, wood chips or sawdust, water, soil and ash.

Sample Collection

The water hyacinth was harvested manually from Pulgaon Nala Durg, in a stream about 5 km from Bharti University.

Water hyacinth compost preparation

Compost was prepared from using water hyacinth (the main source) with other bulking agents (cow manure, rice straw, soil and ash). Cow manure was added to speed up the composting and enhance nutrient levels in the final compost product (Wan *et al.*, 2012), while rice straw was added to adjust the C/N ratio and moisture level for efficient composting (Iqbal *et al.*, 2010). Soil was utilized as a microbial source for organic matter decomposition(Nigussie *et al.*, 2021), and adding ash plays a crucial role in regulating the compost pH levels and enhancing the liming effect of the final compost (fig. 2)(Juárez *et al.*, 2015). Water hyacinth was collected before its flowering stage from Lake Tana, Northwestern Ethiopia (10°45′54.1″ N, 36°10′24.9″ E and 12°50′15.9″ N, 38°50′54.48″ E) at different infested areas of the lake. Cattle manure was collected from the cattle farm of the College of Agriculture and Environmental Sciences (CAES), Bihar Dar University, and rice straw was collected from farmers. Soil and ash were also collected from the CAES campus of Bihar Dar University. Before sun drying, fresh water hyacinth biomass was chopped into smaller pieces (2 - 3 cm). The drying was required to manage the moisture inside the compost mix. After sun drying the biomass for two weeks, the compost mix was made in a 50:30:10:10 ratio (dry weight basis) of water hyacinth, cow manure, rice straw, and a mix of soil and ash, respectively. The compost ingredients and ratios were based on(Roshan *et al.*, 2012), with some modifications of adding soil and ash. During mixing, water was sprinkled. The compost mix was then converted into a composting heap with a volume of 3 m3 (1 m height, 1.5 m width, 2 m length). Plastic sheets covered the inner walls of the compost heap. A rice straw was laid at the base of the composting heap before converting the bulk compost mix. After constructing the compost hip, it was covered with grass to prevent moisture loss and allow air circulation. The compost moisture level was maintained at 60 % for better microbial activity (Gurusamy *et al.*, 2021). The compost mix was turned once a month for better aeration and biomass degradation. The compost matured after four months of composting. Matured compost was air dried, crushed, and screened using a 2-mm and 4-mm sieve for chemical analysis and land application, respectively (Fig. 3).

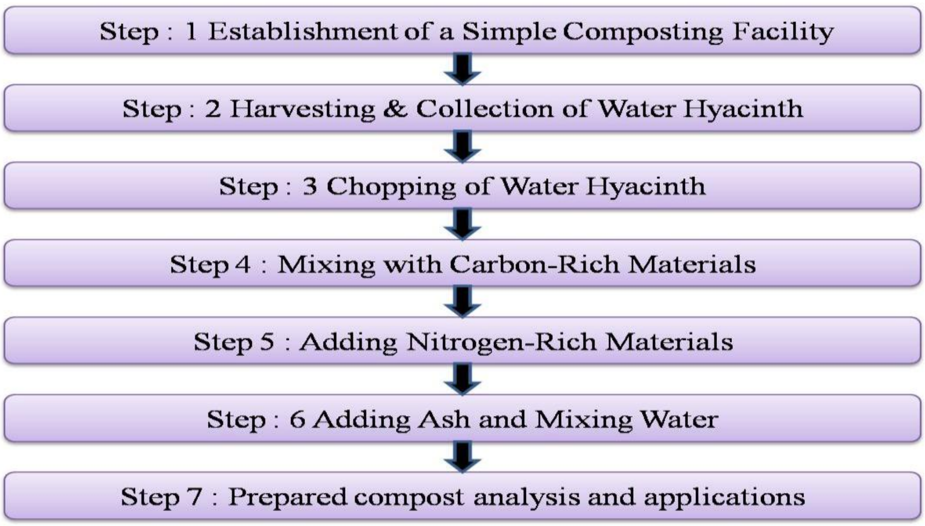

Fig. 2: Applied steps for Compost preparation by using water hyacinth plants

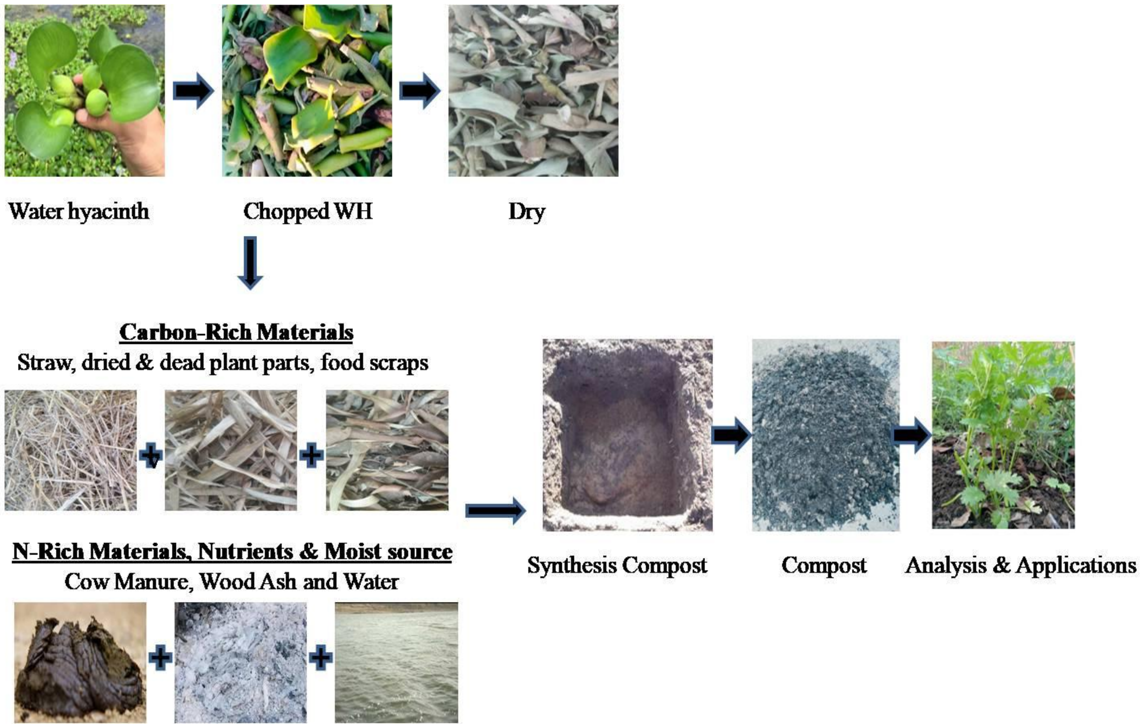

Fig. 3: The compost preparation by using Water hyacinth used process

Compost fertility assay

The main scope of this paper was to analyze that were successfully proven to be appropriate for fertility assays (Agachi *et al.*, 2025). The water hyacinth compost fertilizers capacity was evaluated using pea andpaddyseeds and it's sterilized for five minutes with 0.1% $HgCl_2$ (w/v). Seeds were deep in water (10-10 seeds) &water hyacinth compost extracts solution (10-10 seeds) for 12 hours. All tests were applied to the seeds, and they maintained at room temperature during each treatment. After 48 hours of treatment, the rate of seed germination was assessed. The seeds that had sprouted were moved to separate container that had soil and water hyacinth compost mix soil at the bottom for a substrate. Subsequently, they were subjected to the without compost soil and prepared water hyacinth compost mix soil. The assay was carried out for seven days while the observation maintained. To see any notable changes, the parameters, including the percentage of seed germination, relative root growth, elongation of shooting and rooting, relative root growth %, relative seed germination %, germination index and germination rate index required to be noted (Kalyani *et al.* 2009; Rao and Prasad 2014;Agachi *et al.*, 2025)).

Parameters studied: The characteristics mentioned below were studied.

a) Seed germination %: The following formula was used to calculate the percentage of seed germination:

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds}} \times 100$$

b). Elongation of shooting and rooting: Root length (RL) and shoot length (SL) was measured in each of the seedlings corresponding to each used of water hyacinth compost and controls.

c). Relative root growth %: For every experimental set, the root lengths of the water hyacinth compost extracts solution and the control (water) were measured. The main root's end to the hypocotyl's base was used to measure the root's length. The relative root growth (RRG) was calculated using Equation to get its percentage.

$$\text{RRG \%} = \frac{\text{Mean root of length in WH compost extract}}{\text{Mean root length in control}} \times 100$$

d). Relative seed germination: Using Equation, the relative seed germination (RSG) was calculated.

$$RSG\ \% = \frac{\text{No. of seeds germinated in WH compost extract}}{\text{Number of seeds germinated in control}} \times 100$$

e). Germination index: It was calculated according to with formal seed analysis criteria and represents the estimated germination rate of seedlings.

$$GI\% = \frac{RSG \times RRG}{100}$$

f). Germination rate index: The germination rate index was calculated by dividing the germination index by the germination percentage for each treatment and replication.

$$GRI = \frac{\text{Germination index}}{\text{Germination }\%}$$

Statistical analysis

The results are mean ± standard deviation, and all research experiments were carried out in triplicate (n = 3). Means and standard deviations were used to show the data. MS software was used for each statistical procedure

RESULTS AND DISCUSSION

Compost fertilizer effect

The fertilizer effect test showed that water hyacinth compost extract did not inhibit the germination of pea and paddy seeds. As depicted in water hyacinth compost extract solution resulted in a germination rate (GR) of ≥ 80 % and > 100 % for pea and paddy seeds, respectively. Similarly, the control without compost resulted in a germination rate (GR) of ≥ 70 % and > 90 % for pea and paddy seeds, respectively.The pea and paddy seeds in the water hyacinth compost had relative root growth, relative seed germination, germination index and germination rate index % of 182.85%, 163.91%, 114.28, 111.11, 209.94, 182.12, 2.62 and 1.82 respectively. The elongation of shooting and rooting were showed in table1. Water hyacinth compost contains nutrients like nitrogen, phosphorus, and potassium that are beneficial for plant growth. The presence of these nutrients helps plants grow taller and stronger. Using water hyacinth compost can also improve plant quality. The nutrients and other compounds present in the compost help plants become healthy and robust. Several studies have found that using water hyacinth compost can improve plant height and quality. For example, our study found that using water hyacinth compost increased the height of paddy and pea plants compared then water treat.

Table1: Effect of used compost on root and shoot elongation of pea and paddy seedlings

Seed	Sample	Root length (cm)	Shoot length (cm)
Pea	Without compost	1.05±0.49	1.72±0.56
	Used compost	1.92±0.37	2.38±0.36
Paddy	Without compost	1.94±0.69	3.25±0.40
	Used compost	3.18±0.28	4.24±0.55

When utilized compost was applied to pea and paddy seedlings, it improved both root and shoot growth compared to the control.Compost treatment enhanced root length in pea seedlings from 1.05 ± 0.49 cm to 1.92 ± 0.37 cm and shoot length from 1.72 ± 0.56 cm to 2.38 ± 0.36 cm.Similarly, adding compost to paddy seedlings improved their growth. The root length rose from 1.94 ± 0.69 cm to 3.18 ± 0.28 cm, whereas the shoot length increased from 3.25 ± 0.40 cm to 4.24 ± 0.55 cm.Overall, the findings suggest that utilized compost enhances early seedling growth by increasing root and shoot elongation.

CONCLUSION

The current study shows that water hyacinth (Eichhornia crassipes), an invasive aquatic weed, may be effectively converted into a beneficial organic fertilizer by controlled composting with appropriate bulking agents such as cow dung, rice straw, soil, and ash. The composting technique produced a mature, stable, and non-phytotoxic compost, as evidenced by a germination index of over 80% and improved early growth responses in pea and paddy seedlings. When compared to the control soil, the created compost showed significant improvements in seed germination, root and shoot elongation, and overall seedling vigor, indicating that it has agronomic potential.

The findings show that water hyacinth compost contains important plant nutrients and promotes healthy plant growth while improving soil quality. Furthermore, the composting process aids in the detoxification of bioactive phytochemicals found in plant material, lowering potential phytotoxic effects and boosting humification. This strategy combines invasive species management and sustainable nutrient recycling by transforming an environmentally harmful weed into a positive agricultural input.

Overall, the study supports the use of water hyacinth compost as a low-cost, environmentally benign alternative to chemical fertilizers, especially in small-scale and sustainable farming systems. The findings help to advance circular bioeconomy initiatives by promoting waste-to-resource conversion, minimizing environmental pollution, and supporting sustainable agriculture practices. More long-term field research and metal mobility assessments are needed to strengthen guidelines for large-scale use.

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REFERENCES

Abba, A., Kumar, R., and Singh, M. (2025) Advancing circular bioeconomy through systematic review of multi-product biorefinery approaches for water hyacinth-based renewable energy. *Science, **36***, Article 106068.

Agachi, B.V., Vulpe, C.B., Cosma, C.A., Istrate, D., Pujicic, A., and Iachimov-Datcu, A. D. (2025) Comparative evaluation of standardized methods for phytotoxicity testing. *Annals of West University of Timisoara: Series of Biology*, ***28***(1).

Ahmed, F. E., Hassan, M. A., and El-Sharkawy, S. (2025) *Investigating the tannin content and phytochemical composition of water hyacinth (Eichhornia crassipes).* Journal of Environmental Chemistry, **18**(2), 112–121.

Bakrim, W.B., El-Ghouati, A., Bouyahya, A., El Omari, N., and El Menyiy, N. (2025) Phytochemical profiling, biological activities, and in-silico molecular docking studies of *Eichhornia crassipes* aerial extracts. *Journal of Molecular Structure*, **1305**, Article 136545.

Begum, S.L.R. (2021) Potential of water hyacinth (*Eichhornia crassipes*) as compost and its effects on soil and plant properties: A review. *Agricultural Reviews, **42***(2), 123–131.

Canning, A. (2025) *A review on harnessing the invasive water hyacinth (Eichhornia crassipes) for use as an agricultural soil amendment*. *Land, **14***(5), 1116.

Deshlahre, A., and Kulkarni, P. (2025) Phytochemical analysis and antioxidant potential of *Eichhornia crassipes* leaf extracts. *Spectrum of Emerging Sciences*, **4**(2), 55–63.

Dushimeyesu, E., Habimana, S., Munyandamutsa, F., Rugwiro, P., Mubashankwaya, I., and Nyiransabimana, D. (2024) The effect of water hyacinth (*Eichhornia crassipes*) organic fertilizer on the vegetative growth of carrot (Daucus carota), Royal Chantenay variety. *Turkish Journal of Agriculture - Food Science and Technology*, **12**(2), 268–273.

Febriani, A., Manalu, R. T., and Damanik, N. D. (2024) Exploring the antibacterial potential of water hyacinth (*Eichhornia crassipes*) against *Staphylococcus epidermidis* and *Propionibacterium acnes*. *International Journal of Microbial Bioprospecting*, **11**(3), 98–105.

Gaurav, G.K., Soni, A., and Chopra, A. (2020) Water hyacinth as a biomass: A review. *Journal of Cleaner Production*, **261**, 122214.

Gurusamy, N. N., Puffer, N., De Jongh, C., Gil, C. R., and Aspray, T. J. (2021) Effect of initial moisture content and sample storage duration on compost stability using the ORG0020 dynamic respiration test. *Waste Management*, ***125*,** 215-219.

Hasnat, H., Rahman, M.M., Islam, S., Rahaman, M.S., and Mahmud, I. (2024) GC–MS/MS and bioactivity profiling of methanolic flower extract of *Eichhornia crassipes*. *Journal of Pharmacognosy and Phytochemistry*, **13**(1), 201–212.

Iqbal, M.K., Shafiq, T., and Ahmed, K. (2010) Characterization of bulking agents and its effects on physical properties of compost. *BioresourceTechnology*, ***101***(6), 1913-1919.

Juárez, M.F.D., Gómez-Brandón, M., and Insam, H. (2015) Merging two waste streams, wood ash and biowaste, results in improved composting process and end products. *Science of the Total Environment*, ***511***, 91-100.

Kalyani, D.C., Telke, A. A., Dhanve, R.S., and Jadhav, J.P. (2009) Ecofriendly biodegradation and detoxification of Reactive Red 2 textile dye by newly isolated Pseudomonas sp. SUK1. *Journal of hazardous materials*, 1***63***(2-3), 735-742.

Korkmaz, N., Arslan, H., & Yıldırım, T. (2025) Artificial intelligence-assisted optimisation of extraction conditions to enhance phenolic and flavonoid yield from *Eichhornia crassipes*. *Scientific Reports,* ***15***(1), Article 2694.

Mazumder, M. (2021). Heavy-metal risk assessment of water-hyacinth-based compost in crop production. *Environmental Agriculture Review*, **15**(4), 201–212.

Nandiyanto, A. B. D., Ragadhita, R., Hofifah, S. N., Al Husaeni, D. F., Al Husaeni, D. N., &Fiandini, M. (2024). Progress in the utilization of water hyacinth as effective biomass material. *Environment, Development and Sustainability,* ***26***(10), 24521–24568.

Nigussie, A., Dume, B., Ahmed, M., Mamuye, M., Ambaw, G., Berhiun, G., and Aticho, A. (2021) Effect of microbial inoculation on nutrient turnover and lignocellulose degradation during composting: A meta-analysis. *Waste Management*, ***125*,** 220-234.

Patinha, C., Silva, C., Neves, R., Pato, P., and others. (2025) *Water hyacinth (Eichhornia crassipes) biomass characterization for a potential exploration as an agriculture soil enhancer: Linking multi-location biogeochemical profiles to ecotoxicological safety.* Environmental Chemistry and Ecotoxicology, 8.

Rao, K. B., and Prasad, A. A. (2014) Biodecolourisation of azo dye reactive red 22 by Bacillus infantis strain AAA isolated from seawater and toxicity assessment of degraded metabolites. *Nature Environment and Pollution Technology*, ***13***(2), 369.

Roshan Singh, W., Das, A., and Kalamdhad, A. (2012) Composting of water hyacinth using a pilot scale rotary drum composter. *Environmental Engineering Research*, ***17***(2), 69-75.

Serafini, L.F. (2025) *Optimizing large-scale composting systems for water hyacinth residues using vermicompost enhancement. Waste Management & Research*, **43**(1), 15–29.

Serafini, L.F., Arrobas, M., Rodrigues, M.Â., Feliciano, M., Miguens, F., Oliveira, V., Santos, D., Díaz de Tuesta, J. L., and Gonçalves, A. (2024) The composting of water hyacinth: A life cycle assessment perspective. *Waste and Biomass Valorization*, **16**(1), 507–523.

Shukla, A., Tiwari, R., and Verma, P. K. (2023) Evaluation of antioxidant activity in hydro-ethanolic extracts of *Eichhornia crassipes* leaves. *Nano Bio Letters*, **15**(4), 221–230.

Vincent-Akpu, I. F., Ogbonna, D., and Tongo, I. (2024) Nutrient and heavy-metal evaluation of water-hyacinth compost for agricultural use. *South African Journal of Science*, **120**(2), 50–61.

Wan, S., Xi, B., Xia, X., Li, M., Wang, L., and Song, C. (2012) Using fluorescence excitation–emission matrix spectroscopy to monitor the conversion of organic matter during anaerobic co-digestion of cattle dung and duck manure. *Bioresource Technology*, ***123***, 439-444.