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"Warning in Spaces: Blending Heritage, Nature and Design"

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"Harmony in Spaces : Blending Heritage, Nature and Design"

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05-3742716
uitmperakpress@gmail.com

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Effectiveness of Phytoremediation in the Constructed Wetlands of UiTM Perak, Seri Iskandar Campus, Perak.

Nur Aiman Widad Rosli¹, Atikah Fukaihah Amir²

^{1,2} *Department of Built Environment Studies and Technology, Faculty of Built Environment, Universiti Teknologi MARA Seri Iskandar, 32610 Seri Iskandar, Perak*

Abstract

Wastewater is often released into nearby lakes without proper treatment, causing pollutants like nutrients and suspended solids to build up. This can harm water quality, disrupt aquatic ecosystems, and lead to problems such as eutrophication, bad odors, and reduced ecological health, affecting both the environment and local communities. To tackle this, constructed wetlands have been introduced as a sustainable, nature-based solution to treat wastewater before it enters natural water bodies. These wetlands use phytoremediation, where aquatic plants and microorganisms naturally absorb, break down, and stabilize pollutants, improving water quality through biological processes. This study aims to evaluate the effectiveness of phytoremediation in the constructed wetlands of UiTM Seri Iskandar, focusing on its capability to improve water quality and promote sustainable environmental management. A quantitative research design was employed to assess key physical and biological water quality parameters, including pH, electrical conductivity (EC), Ammonia (NH₄), Nitrite (NO₂), Nitrate (NO₃), and TDS. Water samples were collected in December 2025 from the four different constructed wetland systems to determine pollutant reduction efficiency across the treatment system. The findings of this research demonstrate that phytoremediation effectively improves water quality, supporting the role of constructed wetlands as sustainable, low-cost solutions for ecological water treatment within landscape design.

Keyword: Phytoremediation, Constructed Wetlands, Water Quality, UiTM Seri Iskandar, Sustainable Landscape

INTRODUCTION

In many developing areas, untreated wastewater is frequently discharged directly into lakes, rivers, and other natural water bodies, leading to the accumulation of pollutants and deterioration of aquatic ecosystems. Wastewater issues have also been identified around UiTM Perak, where inflow into nearby ponds or constructed lakes has led to increased nutrient levels, sediment buildup, and potential contamination. The ongoing discharge of untreated or partially treated wastewater can trigger eutrophication, oxygen depletion, and habitat decline, ultimately affecting aquatic biodiversity and water quality (World Health Organization, 2023). These concerns emphasize the need for sustainable and low-cost treatment systems that can reduce pollutant loads before wastewater enters natural ecosystems. As wastewater travels through the lake, it naturally undergoes several filtering processes that help remove pollutants.

Constructed wetlands are widely recognized as an effective solution due to their high purification efficiency, low maintenance requirements, and reliance on natural processes (Kataki et al., 2021). The water purification capability of wetlands is now being recognized as an attractive option in wastewater treatment due to its multi-pollutant treatment capability, low cost, and ease of operation (Herath & Vithanage, 2015). They imitate natural wetland functions by using soil, microorganisms, and vegetation to remove contaminants. A key mechanism within these systems is phytoremediation, where aquatic plants absorb, break down, or stabilize pollutants such as heavy metals and excess nutrients. However, the performance of phytoremediation varies depending on plant species, contaminant levels, soil conditions, and local climate, which can influence its overall consistency across different sites.

This study supports the Sustainable Development Goals (SDGs), particularly Goal 6: Clean Water and Sanitation and Goal 15: Life on Land, which emphasize the protection and restoration of natural ecosystems while ensuring safe and sustainable water management. It also aligns with Environmental, Social, and Governance (ESG) principles by promoting environmentally responsible wastewater treatment, enhancing community health, and supporting transparent and sustainable resource management. In addition, this study contributes to the Malaysia MADANI vision by advancing sustainability, environmental stewardship, and community well-being through the adoption of nature-based solutions such as constructed wetlands.

This research focuses on assessing the effectiveness of phytoremediation in the constructed wetlands of UiTM Seri Iskandar. The objectives of this study are i) to assess the current water quality conditions within the constructed wetlands of UiTM Seri Iskandar, ii) to evaluate the effectiveness of phytoremediation in reducing pollutants across different treatment zones, and iii) to determine the potential of constructed wetlands as sustainable water management and landscape treatment systems. At UiTM Perak, Seri Iskandar Campus, constructed wetlands serve as part of the campus's green infrastructure, managing surface runoff and improving water quality. However, limited research has been conducted to evaluate their actual performance and the efficiency of phytoremediation within this system. Assessing the effectiveness of phytoremediation in the constructed wetlands is crucial for understanding their role in pollution control, ecological enhancement, and sustainable landscape management.

LITERATURE REVIEW

Phytoremediation

Phytoremediation is a method that uses green plants to clean and treat polluted water, soil, and air. However, not every plant can absorb heavy metals or organic pollutants because each species has different physiological abilities (Georgin et al., 2025). Even plants from the same species can vary in how well they take up pollutants. Several phytoremediation mechanisms operate within constructed wetlands, including phytoextraction, where contaminants are absorbed and accumulated in plant tissues, phytostabilisation, which immobilises pollutants in the sediment; phytodegradation and rhizodegradation, where contaminants are broken down through plant and root-associated microbial processes, phytovolatilisation, involving the release of transformed contaminants into the atmosphere; and phytofiltration, where roots filter and adsorb pollutants from the water column. Overall, phytoremediation offers a green and sustainable approach to managing pollution, but it needs proper planning and execution to ensure effective outcomes (Kalimoldina et al., 2025).

Constructed Wetlands

A constructed wetland is a man-made or engineered system designed to simulate the natural processes of a wetland, treating wastewater. It uses soil, plants, and microorganisms to naturally filter and remove pollutants such as nutrients, organic matter, and heavy metals from domestic, agricultural, or industrial water. Unlike natural wetlands, constructed wetlands are carefully planned and built to manage water quality, reduce pollution, and support environmental sustainability while often providing additional benefits like wildlife habitat and aesthetic value (Dykes et al., 2025).

Water Quality Index

The Water Quality Index (WQI) is a numerical tool used to evaluate and represent the overall quality of water in a simple and understandable form. It combines various physical, chemical, and biological parameters, such as pH, temperature, dissolved oxygen, and turbidity, into a single score that typically ranges from 0 to 100, where higher values indicate better water quality. Based on WQI values, water bodies can be classified into different water quality classes with specific designated uses (DOE Malaysia, 2026). Class I indicates very high-quality water, suitable for conserving the natural environment, with a water supply

requiring practically no treatment, and fisheries involving very sensitive aquatic species. Class IIA represents water suitable for water supply with conventional treatment and supports sensitive aquatic species, while Class IIB is suitable for recreational use. Class III water requires extensive treatment for the water supply and supports common, tolerant aquatic species, including livestock drinking. Class IV water is mainly suitable for irrigation purposes, whereas Class V indicates very poor water quality that does not meet any of the stated uses. By summarising complex water quality data into a single index and linking it to functional classifications, the WQI serves as an important decision-making tool for researchers, policymakers, and water resource managers in assessing and managing water bodies (S. Chidiac et al., 2023).

Water Quality Parameters

Water quality parameters refer to the evaluation of water quality through physical, chemical, and biological indicators, based on monitoring data and certain evaluation standards and methods. Each parameter provides essential information about pollution levels and ecosystem health. Water quality parameters such as pH, electrical conductivity (EC), ammonia, nitrite, nitrate, total dissolved solids (TDS), and temperature are important indicators of water condition. pH shows whether water is acidic or alkaline and affects aquatic life, while EC indicates the amount of dissolved ions in water. Ammonia, nitrite, and nitrate reflect pollution and nutrient levels related to the nitrogen cycle, which can impact ecosystem health. TDS represents the amount of dissolved substances in water, and temperature influences chemical reactions and biological processes. Together, these parameters provide a general overview of water quality. These characteristics are assessed through measurements of physical traits, as well as chemical and biological indicators, which together reflect the overall condition of the water body (*Water Quality Parameters - Classification and Different Requirements*, 2024).

Effectiveness of Plant Species

The performance of phytoremediation strongly depends on the choice of plant species, the predominance of particular contaminants, substrate conditions, and operational parameters. The study found that different aquatic macrophytes exhibited varying efficiencies in pollutant removal under colder temperatures, and that

wetland systems planted with certain species achieved higher nutrient and organic matter elimination than others. These findings highlight the importance of carefully selecting suitable plant species and designing tailored treatment configurations to optimise phytoremediation outcomes in constructed wetlands (Huang et al., 2024).

RESEARCH METHODOLOGY

Research Design

This study adopts a quantitative method to measure the effectiveness of phytoremediation in improving water quality in the constructed wetlands of UiTM Perak, Seri Iskandar Campus. The assessment focuses on evaluating the effectiveness of phytoremediation in enhancing water quality within the constructed wetlands of UiTM Perak and determining its potential application as a sustainable, nature-based treatment approach for landscape and environmental management. Ecological observations were conducted to complement the water quality measurements collected at the constructed wetland, which focused on several environmental indicators. A structured ecological observation checklist was used to ensure consistency and accuracy during data collection across all sampling stations. By integrating ecological observations with water quality testing, the methodology provided a more comprehensive assessment of the wetland's overall performance. This combined approach enabled the linking of measurable reductions in pollutants with visible environmental improvements, allowing for a clearer evaluation of the effectiveness of the phytoremediation process within the constructed wetland system.

Site Selection

The research was conducted at the lakes located at UiTM Seri Iskandar, Perak. The site, located at 4°21'41.1"N 100°57'27.8"E, covers a catchment area of approximately 5.86 acres. This constructed wetland was selected based on its accessibility, functional design, and representation of a typical phytoremediation system within the UiTM Seri Iskandar campus. Its strategic location and diverse plant species make it suitable for evaluating the effectiveness of phytoremediation in improving water quality. Figure 1 shows the location of the study area, and Figure 2 shows the location of the sampling stations, while Table 1 presents the description of the sampling points.



Figure 1: Location of water sampling (Tasik UiTM Kampus Seri Iskandar)

Table 1. Sampling site description

No	Site / Source	Site Description	Coordinate
S1	Constructed Wetland 1	The starting point where water enters the constructed wetland. The water here is usually more polluted before treatment begins.	4°21'40.4"N 100°57'24.1"E
S2	Constructed Wetland 2	The section where plants help filter and clean the dirty water through natural processes.	4°21'41.3"N 100°57'25.8"E
S3	Constructed Wetland 3	The main pond that holds water and supports aquatic life such as fish and plants. Helps in filtering the polluted water before the water flows out.	4°21'41.1"N 100°57'27.8"E
S4	Constructed Wetland 4	The last point where treated and cleaner water flows out from the wetland system.	4°21'43.4"N 100°57'28.5"E



Figure 2: Location of sampling stations

Sampling Procedure

Water sampling was conducted under various weather conditions, including sunny days and misty weather, in four constructed wetlands to ensure that the collected data represented a range of natural environmental situations. A total of four sampling stations were established within the constructed wetlands of UiTM Perak to represent different treatment zones, including the inlet (before treatment), middle (within vegetation), and outlet (after treatment) areas (Figure 2). Each station consisted of three sampling points to provide adequate spatial coverage and to ensure that the collected data accurately represented variations in water quality as the water flowed through the phytoremediation system.

At each station, six parameters were measured using portable water testing instruments:

- pH
- Electrical Conductivity (EC)
- Ammonia (NH₄)
- Nitrite (NO₂)
- Nitrate (NO₃)
- TDS

Measurements were taken **in situ**, recorded immediately, and averaged across the three points at each station to obtain representative values based on figures 3, 4, and 5.



Figure 3: Water sampling process at CW1 and CW2

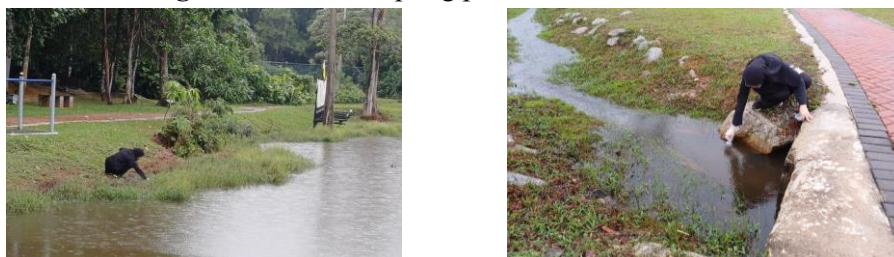


Figure 4: Water sampling process at CW3 and CW4



Figure 5: In-situ Measurement and Laboratory Analysis

Data Analysis

The collected data were analysed using descriptive statistical methods, including the calculation of mean values and ranges for each measured parameter. The results were compared between the inlet, middle, and outlet sampling stations to determine changes in water quality throughout the constructed wetland. This comparison indicates the effectiveness of phytoremediation in reducing pollutants. The analysed data were also evaluated against the Department of Environment (DOE) Malaysia Water Quality Standards (2017) in Table 2 to classify the water quality level after treatment. This analysis helps to determine the performance of the constructed wetland as a natural filtration system and its potential application as a sustainable phytoremediation model for environmental and landscape management.

Table 2. National Water Quality Index

Class	Uses
I	Conservation of the natural environment. Water Supply I- Practically no treatment necessary. Fishery I - Very sensitive aquatic species.
IIA IIB	Water Supply II - Conventional treatment required. Fishery II - Sensitive aquatic species. Recreational use with body contact.
III	Water Supply III - Extensive treatment required. Fishery III - Common, of economic value, and tolerant species; livestock drinking.
IV	Irrigation
V	None of the above.

Source: Department of Environment

ANALYSIS AND DISCUSSION

Data Collection

The instruments used in this study were designed to measure key water quality parameters in the constructed wetlands of UiTM Perak, Seri Iskandar Campus. On-site measurements were taken using portable testing devices, while all readings followed the standard procedures recommended by the Department of Environment (DOE) Malaysia. Table 3 presents the water sampling data collected during misty weather and sunny days, including both the measured values and the average values of the water quality parameters.

Table 3 presents the water sampling data collected from all constructed wetland zones under the two experiments. The table summarises the measured values and average results for key water quality parameters, including pH, electrical conductivity (EC), ammonia (NH₄), nitrite (NO₂), nitrate (NO₃), and total dissolved solids (TDS). These data provide a basis for comparing water quality variations between different treatment zones and weather conditions, which will be further analyzed and discussed. The results show a decrease in the number of parameters in CW3 and CW4, as shown in the table 3.

Experiment 1 (Misty weather)

Parameter	Unit	CONSTRUCTED WETLAND 1 (CW1)				CONSTRUCTED WETLAND 2 (CW2)				CONSTRUCTED WETLAND 3 (CW3)				CONSTRUCTED WETLAND 4 (CW4)			
		CW1S1	CW1S2	CW1S3	Avg.	CW2S1	CW2S2	CW2S3	Avg.	CW3S1	CW3S2	CW3S3	Avg.	CW4S1	CW4S2	CW4S3	Avg.
pH	-	9.10	9.18	9.32	9.2	8.54	8.61	8.75	8.6	8.05	8.19	7.98	8.1	8.19	8.26	8.4	8.3
Electrical conductivity (EC)	µS/cm	63	59	50	57	34	33	57	41	33	32	33	33	33	33	33	33
Ammonia (NH ₄)	mg/L	0.25	0.25	0.25	0.25	0.25	0	0	0.08	0.25	0.25	0.25	0.25	0	0.25	0	0.08
Nitrite (NO ₂)	mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrate (NO ₃)	mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Dissolved Solids (TDS)	mg/L	32	31	25	29	16	16	29	20	17	16	16	16	16	16	17	16

Experiment 2 (Sunny day)

Parameter	Unit	CONSTRUCTED WETLAND 1 (CW1)				CONSTRUCTED WETLAND 2 (CW2)				CONSTRUCTED WETLAND 3 (CW3)				CONSTRUCTED WETLAND 4 (CW4)			
		CW1S1	CW1S2	CW1S3	Avg.	CW2S1	CW2S2	CW2S3	Avg.	CW3S1	CW3S2	CW3S3	Avg.	CW4S1	CW4S2	CW4S3	Avg.
pH	-	8.96	8.61	8.54	8.7	8.40	8.12	7.56	8.03	7.84	7.77	7.84	7.82	7.84	7.77	7.77	7.8
Electrical conductivity (EC)	µS/cm	54	54	46	51	40	64	77	60	37	38	38	38	46	34	41	40
Ammonia (NH ₄)	mg/L	0.25	0.25	0.25	0.25	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0	0.25	0.17
Nitrite (NO ₂)	mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrate (NO ₃)	mg/L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Dissolved Solids (TDS)	mg/L	28	28	23	26	19	31	38	29	18	18	18	18	23	19	21	21

Table 3. Water Sampling Data

Comparison Graph of Water Quality Parameters between Experiment 1 and Experiment 2

Based on Figure 6, the pH values under both Experiment 1 and Experiment 2 show a general decreasing trend from CW2 to CW4, indicating a gradual reduction in alkalinity as water flows through the pond

system. In Experiment 1, pH levels were higher in all constructed wetland zones, ranging from 8.1 to 9.2, showing more alkaline water. In Experiment 2, the pH levels were lower, ranging from 7.8 to 8.7. The higher pH observed during misty weather may be influenced by surface runoff and dilution effects, which can introduce alkaline substances into the system. Such variation can affect nutrient availability and microbial processes that contribute to pH regulation within the wetland environment. These influences highlight how environmental conditions, including weather patterns, must be considered when interpreting pH trends in phytoremediation studies (Nsanabaganwa et al., 2025).

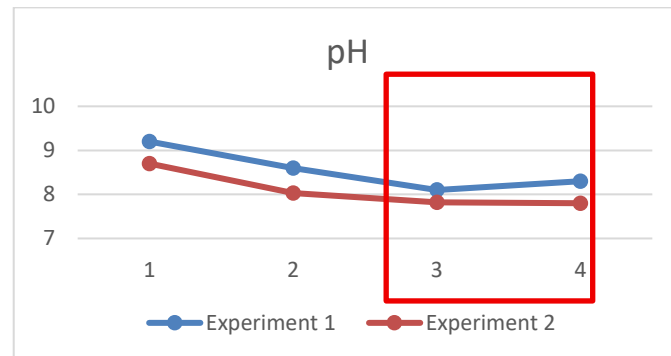


Figure 6: Comparison of pH Values under Experiment 1 and Experiment 2

Based on Figure 7, the electrical conductivity (EC) values for both experiments show an overall decreasing trend across the four constructed wetland sampling points, indicating a reduction in dissolved ionic content as water flows through the pond system. In Experiment 1, EC decreased steadily from CW1 (57 $\mu\text{S}/\text{cm}$) to CW4 (33 $\mu\text{S}/\text{cm}$), suggesting that dilution and effective ion removal occurred along the wetland. In Experiment 2, the EC values showed greater variation, with a notably higher reading at CW2 (60 $\mu\text{S}/\text{cm}$) compared to Experiment 1. This increase in EC during sunny conditions may be attributed to reduced water dilution and increased ion concentration caused by evaporation and lower water inflow. Overall, the constructed wetland zones are effective in improving water quality, consistent with recent findings that constructed wetlands can significantly reduce dissolved ionic content as part of broader water purification mechanisms (Ruiz et al., 2024).

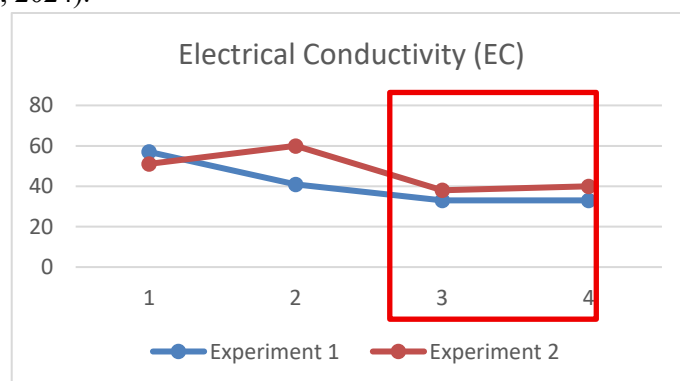


Figure 7: Comparison of EC Values under Experiment 1 and Experiment 2

Ammonia (NH_4) concentrations show noticeable variation across the constructed wetland sampling points under both experiments, as shown in Figure 8. During Experiment 1, ammonia levels were generally low, ranging from 0.08 to 0.25 mg/L, with lower concentrations observed at CW2 and CW4, indicating that dilution and uptake by aquatic vegetation contributed to improved water quality. In Experiment 2, ammonia

levels varied slightly, with higher values recorded at CW3 (0.25 mg/L) and CW4 (0.17 mg/L), which may be attributed to slower water movement and longer water retention during drier conditions, allowing ammonia to accumulate. Despite these variations, ammonia concentrations at all sampling points remained within safe levels, as aquatic organisms were still present at CW3 and CW4 (Yang et al., 2024). The presence of aquatic animals such as fish and tortoises in these zones further indicates that ammonia levels were not harmful and that the wetland environment supports healthy aquatic life. Overall, the results demonstrate that the constructed wetland system effectively controls ammonia levels through the uptake of vegetation and microbial nitrogen transformation processes under both experimental conditions.

Nitrite (NO_2) and nitrate (NO_3) concentrations were recorded as zero across all sampling points during both misty weather and sunny day conditions, indicating that nitrification and nutrient removal processes were effective throughout all constructed wetland zones.

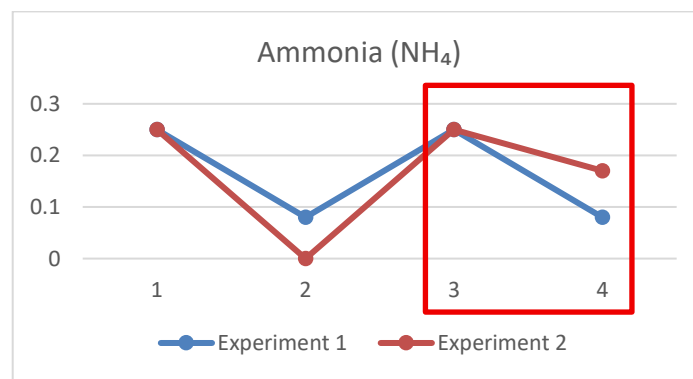


Figure 8: Comparison of Ammonia Values under Experiment 1 and Experiment 2

Based on Figure 9, the Total Dissolved Solids (TDS) values show different patterns between the two experiments but generally indicate effective water quality improvement through the constructed wetland. During Experiment 1, TDS levels were higher at the inlet, particularly at CW1 (29 mg/L), likely due to rainwater runoff introducing more dissolved materials into the system. The TDS values then gradually decreased toward CW4 (16 mg/L), demonstrating the wetland's ability to reduce dissolved solids through filtration, sedimentation, and vegetation uptake. In Experiment 2, TDS levels were slightly lower at the inlet but increased at CW2 and CW4, possibly due to reduced water dilution and higher evaporation under drier conditions. Although the Total Dissolved Solids (TDS) values are very low and often indicate relatively pure water, the observed decreasing trend suggests that the presence of all ponds and surrounding vegetation contributes positively to improving overall water quality by enhancing natural filtration and pollutant removal processes.

The results of this study show that the constructed wetland system at UiTM Seri Iskandar effectively improved water quality through phytoremediation processes. A clear improvement in water quality parameters was observed as water moved from the inlet (CW1) to the outlet (CW4), indicating that the wetland treatment zones functioned as intended (Parde et al., 2020).

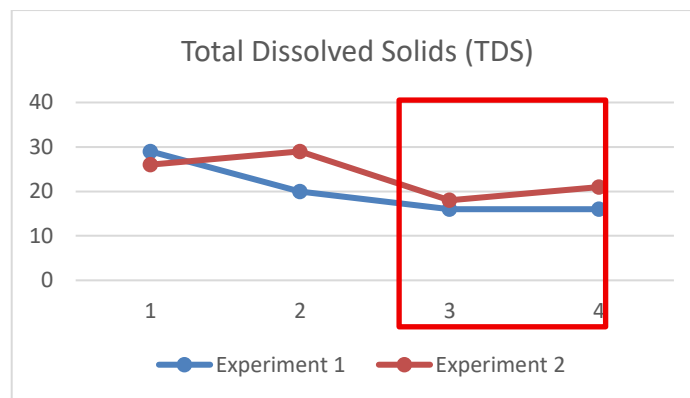


Figure 9: Comparison of TDS Values under Experiment 1 and Experiment 2

Ecological Observation

Constructed Wetland 1 (CW1)

The slightly cloudy water and presence of mild odour in CW1 indicate that this zone functions as the primary inlet where untreated wastewater (greywater) first enters the system. The higher sediment accumulation suggests that CW1 plays an important role in initial sedimentation, allowing heavier particles to settle before water moves to the next treatment zones. Limited aquatic plant coverage explains the lower level of biological treatment at this stage; however, the healthy condition of the plants indicates active nutrient uptake. Low algae growth and the presence of only a few aquatic organisms reflect the higher pollution load and less stable environmental conditions, which are typical of the early treatment stage in a constructed wetland system. Figure 10 shows the Ecological observation and site condition of Constructed Wetland 1 (CW1). The map represents zones with low vegetation cover at CW1, with a percentage of 8%, with plant growth mainly concentrated around the pond edges.

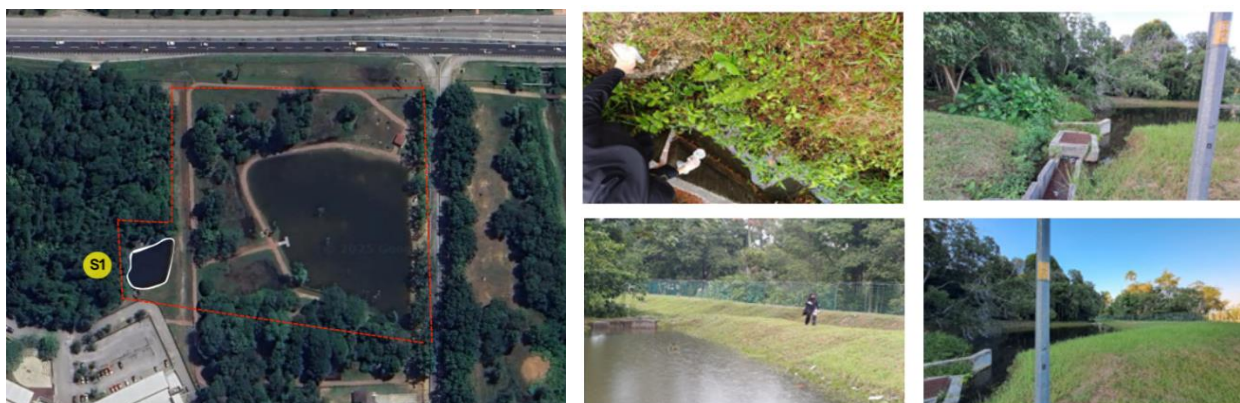


Figure 10: Ecological observation and site condition of Constructed Wetland 1 (CW1)

Species Involved (CW1) - Botanical Name (B.N) Common Name (C.N)

CW1 is the inlet area where polluted water first enters the system. The main plant species found here are *Brachiaria mutica* (Para Grass) and *Dillenia suffruticosa* (Simpoh Air). These plants are tolerant to high nutrient and sediment levels, helping to trap sediments and begin the early removal of pollutants. In constructed wetlands, established wetland vegetation can significantly improve the removal of nutrients and

suspended solids through physical processes like sediment trapping, as well as biological mechanisms such as nutrient uptake and the promotion of microbial degradation in the rhizosphere of wetland plants. (Nandakumar et al., 2019). This explains why water quality is still lower in CW1 compared to the other zones.



B.N: *Brachiaria mutica*
C.N: Para Grass



B.N: *Dillenia suffruticosa*
C.N: Simpoh Air

Constructed Wetland 2 (CW2)

In CW2, as shown in Figure 11, water clarity improved compared to the inlet zone, indicating the effectiveness of the filtration and treatment processes. Odour was minimal or absent, suggesting reduced organic pollution. Aquatic plants in this zone appeared healthy with moderate to high coverage, supporting active phytoremediation. Sediment levels were lower than in CW1, and algae growth remained controlled. The presence of aquatic organisms increased, indicating improved environmental conditions and habitat suitability. CW2 showed higher vegetation coverage in 70%, with plants widely established around the pond and extending into shallow water areas.



Figure 11: Ecological observation and site condition of Constructed Wetland 2 (CW2)

Species Involved (CW2) - Botanical Name (B.N) Common Name (C.N)

CW2 contains denser vegetation, including *Brachiaria mutica*, *Blechnum indicum* (Swamp Water Fern), *Dillenia suffruticosa*, and *Dicranopteris linearis* (False Staghorn Fern). The higher plant density improves filtration and nutrient uptake. These mechanisms together support the observed reduction in ammonia

levels at CW2, indicating that both plant species and wetland vegetation density play important roles in improving water quality.



B.N: *Brachiaria mutica*
C.N: Para Grass



B.N: *Blechnum indicum*
C.N: Swamp Water Fern



B.N: *Dillenia suffruticosa*
C.N: Simpoh Air
B.N: *Dicranopteris linearis*
C.N: False staghorn fern

Constructed Wetland 3 (CW3)

The clearer water and stable conditions observed in CW3 indicate that this zone functions as a stabilisation area within the constructed wetland system. The presence of healthy but minimal aquatic vegetation suggests that major pollutant removal had already occurred in earlier zones, reducing the need for dense plant coverage, as shown in Figure 12. Low to moderate algae growth is likely influenced by increased sunlight exposure and slower water flow, but remains controlled due to improved water quality. The very low sediment accumulation confirms that sediment trapping was effective upstream. The increased presence of aquatic animals, such as fish and tortoises, reflects better water quality and a healthier ecosystem, demonstrating that CW3 provides suitable conditions for aquatic life and ecological balance. The map showed the area with low vegetation cover at CW1 in about 15%, with plant growth mainly concentrated around the pond edges.



Figure 12: Ecological observation and site condition of Constructed Wetland 3 (CW3)

Species Involved (CW3) - Botanical Name (B.N) Common Name (C.N)

CW3 acts as a stabilisation pond where water quality is already improved. The main species found are *Leersia hexandra* (Southern Cutgrass), *Brachiaria mutica*, and *Dillenia suffruticosa*. These plants help maintain water clarity and support aquatic life by stabilising sediments and absorbing remaining nutrients.



B.N: *Brachiaria mutica*
C.N: Para Grass



B.N: *Leersia hexandra*
C.N: Southern cutgrass



B.N: *Dillenia suffruticosa*
C.N: Simpoh Air

Constructed Wetland 4 (CW4)

The clear water observed in CW4, as shown in Figure 13, indicates that the constructed wetland system effectively removed pollutants before water was discharged from the system. There was less odour, and minimal sediment was found. Aquatic plants remained healthy, although plant density was slightly lower due to faster water flow. Minimal algae growth and the presence of aquatic organisms further demonstrate that CW4 functions as an effective polishing zone, producing improved water quality and stable ecological conditions at the outlet of the wetland system. Based on Figure 13, CW4 showed high vegetation coverage of more than 70%, indicating a well-vegetated and functionally effective constructed wetland.



Figure 13: Ecological observation and site condition of Constructed Wetland 4 (CW4)
Species Involved (CW4) - Botanical Name (B.N) Common Name (C.N)

CW4 is the final treatment zone before water leaves the wetland system. Species such as *Eleocharis palustris* (Common Spikerush), *Dillenia suffruticosa*, and *Dicranopteris linearis* are present. These plants help remove remaining pollutants and improve overall water quality, resulting in clearer water with lower ammonia and EC levels.



B.N: *Eleocharis palustris*
C.N: Common Spikerush



B.N: *Dillenia suffruticosa*
C.N: Simpoh Air



B.N: *Dicranopteris linearis*
C.N: False staghorn fern

CONCLUSION

This study assessed the effectiveness of phytoremediation in improving water quality within the constructed wetlands of UiTM Seri Iskandar. The findings show that the constructed wetland system effectively enhances water quality as wastewater flows through successive treatment zones.

The analysis of water quality parameters shows clear improvement trends, with pH values decreasing gradually along the wetland system, indicating better stabilisation of water conditions. Electrical conductivity (EC) values generally declined from CW1 to CW4, reflecting effective removal of dissolved ions through sedimentation, filtration, and plant uptake. Ammonia concentrations were successfully reduced, particularly in zones with higher vegetation density such as CW2 and CW4, where ammonia levels improved from Class II to Class I based on the National Water Quality Standards. Nitrite and nitrate concentrations were consistently recorded as zero across all sampling points, indicating effective nutrient transformation and removal processes within the wetland system. Although Total Dissolved Solids (TDS) values were already low, the decreasing trend further suggests that the ponds and surrounding vegetation contribute positively to natural filtration and water purification.

Ecological observations strongly supported the quantitative data. CW1, which functions as the inlet zone, showed higher turbidity, sediment accumulation, and mild odour, indicating the presence of untreated wastewater. As water moved into CW2 and CW3, improvements in clarity, reduced odour, lower sediment levels, and increased aquatic organisms were observed. CW4 exhibited the clearest water and the most stable ecological conditions, demonstrating the effectiveness of the wetland system before water discharge. The increasing presence of fish, turtles, and other aquatic organisms in downstream zones reflects improved habitat quality and ecological health.

The plant species present in each constructed wetland zone played an important role in the phytoremediation process. Species in CW1 helped tolerate high nutrient loads and trap sediments at the early stage of treatment. CW2 showed the highest plant diversity and density, which contributed significantly to nutrient uptake and ammonia reduction. CW3 acted as a stabilisation zone; the species present helped maintain water clarity and support aquatic life. In CW4, the species further enhanced final pollutant removal, resulting in clearer water with lower EC and ammonia levels. This demonstrates that plant selection and vegetation density are key factors influencing phytoremediation performance. However, this study has several limitations. The scope of water quality analysis was constrained by the

availability and precision of monitoring equipment, which limited the range of parameters measured. Additionally, the relatively short duration of the study restricted the ability to capture long-term variations and the sustained performance of phytoremediation processes over time.

In conclusion, phytoremediation within constructed wetlands at UiTM Seri Iskandar has proven to be an effective and sustainable approach for improving water quality, supporting ecological health, and contributing to environmentally responsible landscape management. This study reinforces the potential of constructed wetlands as practical green infrastructure solutions aligned with sustainable development and environmental stewardship goals.

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