Comparative Efficiency of Aquatic Plant Communities in Improving Water Quality Along a Natural Flow System at Thaksin University, Phatthalung Campus, Thailand

Authors

Thapanee Saisanguan
Ananya Intarasombat
Chetchaiphat Nunseng

School

Paphayomphittayakom School, Phatthalung, Thailand

Advisors

Pornpawit Tabchum
Kanatip Baolai
Apisit Nuikhong

Abstract

Freshwater channels within Thaksin University (Phatthalung Campus) flow through sequential reaches dominated by different aquatic plant communities: (1) a Leafy Bladderwort reach (*Utricularia aurea* Lour) (2) a lotus reach (Nelumbo sp.), and (3) a Yellow Velvet Leaf reach (*Limnocharis flava*). This study asked whether different plant communities measurably influence water quality along the same flow path and across seasonal hydrologic conditions. Water quality was measured at three zones within each plant reach—upstream (before entering the plant reach), midstream (within the plant reach), and downstream (after passing the plant reach)—during October 2025 (early rainy season), November 2025 (flood period), and January 2026 (cool/dry period). Five indicators were analyzed: dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), water temperature, and pH ($n = 27$ observations; 9 per plant community). One-way ANOVA tested differences among plant communities and Bonferroni post hoc tests identified pairwise contrasts. Across all samples, DO ranged 5.5–9.5 mg/L; EC 89–210 µS/cm; TDS 27–104 mg/L; temperature 26.0–28.5 °C; and pH 5.15–7.78. Plant community significantly affected EC ($F = 4.812$, $p = 0.017$), TDS ($F = 5.113$, $p = 0.014$), and temperature ($F = 6.117$, $p = 0.007$), but not DO ($p = 0.540$) or pH ($p = 0.838$). Post hoc tests indicated that the Yellow Velvet Leaf reach had significantly higher EC and TDS than both the Leafy Bladderwort and lotus reaches ($p < 0.05$), and higher temperature than the Leafy Bladderwort reach ($p < 0.01$). Flow-based percent change from upstream to downstream suggested that Leafy Bladderwort and lotus reaches more often reduced EC/TDS, while the Yellow Velvet Leaf reach frequently showed increases. These results support nature-based water treatment planning by highlighting how different local plant communities can either improve or deteriorate key physicochemical indicators along a natural flow system.

Keywords: aquatic plants; natural filtration; water quality; electrical conductivity; total dissolved solids

1. Research Questions

1. Do water quality indicators (DO, EC, TDS, temperature, pH) differ among reaches dominated by different aquatic plant communities along the same flow system?
2. Which indicators show the strongest plant-associated differences and what is the magnitude of the plant effect?
3. How do upstream-to-downstream changes (percent change) vary by plant community and by season (rainy, flood, cool/dry)?

2. Introduction and Review of Literature

Natural and constructed wetlands are widely used as nature-based solutions for improving water quality by reducing dissolved ions, suspended particles, nutrients, and pathogens. Macrophyte communities influence hydrodynamics, sedimentation, microbial processes, and biogeochemical cycling, which can alter conductivity/TDS and temperature regimes along flow paths. Evidence from constructed wetland studies shows that aquatic macrophytes can substantially remove chemical contaminants and modify physicochemical properties of inflowing waters. Lotus (Nelumbo nucifera) has been investigated as a low-cost bioremediation crop for nutrient reduction, while emergent macrophytes such as Yellow Velvet Leaf geniculata have been used in treatment wetlands to reduce a range of pollutants. Filamentous algae can act as biofilters through adsorption and entrapment of particulates, and through oxygen dynamics in photosynthetic mats. However, plant effects can be context-dependent: in some settings, dense vegetation may enhance organic matter accumulation and increase dissolved solids. Therefore, locally grounded comparisons are necessary to inform plant selection for sustainable water treatment and campus-scale environmental management.

3. Research Methods

3.1 Study site:

The study was conducted along a continuous natural freshwater flow system located within Thaksin University, Phatthalung Campus, southern Thailand (7°N, 100°E). The area is characterized by a tropical monsoon climate with a distinct rainy season (May–November) and dry–cool season (December–February). The stream flows through a series of shallow wetland reaches dominated by different aquatic plant communities, providing an ideal natural laboratory to investigate the influence of vegetation on longitudinal water quality changes.

Three representative plant-dominated reaches were selected:

Reach 1: Submerged and filamentous plant community dominated by *Utricularia aurea*

Reach 2: Floating-leaved macrophyte community dominated by Nelumbo nucifera

Reach 3: Emergent macrophyte community dominated by Limnocharis flava

Each reach was hydraulically connected, allowing the same body of water to flow sequentially through upstream, midstream, and downstream zones, thus minimizing background variation and enabling direct comparison of plant effects.

3.2 Sampling Design and Field Measurements

At each plant reach, three sampling zones were established:

Upstream (U): before water entered the plant-dominated area

Midstream (M): within the plant stand

Downstream (D): after water passed through the plant stand

Sampling was conducted during three contrasting seasonal periods:

1. Early rainy season – October 2025
2. Flood season – November 2025
3. Cool–dry season – January 2026

This design yielded a total of 27 sampling points (3 plant types × 3 zones × 3 seasons). At each point, the following physicochemical parameters were measured in situ using calibrated portable probes following GLOBE Water Protocols:

- Dissolved Oxygen (DO, mg L^{-1})
- Electrical Conductivity (EC, μS cm^{-1})
- Total Dissolved Solids (TDS, mg L^{-1})
- Water Temperature (°C)
- pH

All measurements were performed in triplicate to ensure reliability, and mean values were used for subsequent analyses.

3.3 Data Analysis

Descriptive statistics (mean, standard deviation, minimum, and maximum) were calculated for each parameter by plant type and sampling zone. To evaluate whether plant community type significantly affected water quality, one-way Analysis of Variance (ANOVA) was applied separately for each variable (DO, EC, TDS, temperature, and pH). When significant differences were detected ($p < 0.05$), Bonferroni post hoc tests were used to identify pairwise differences among plant types.

To quantify the filtration efficiency of each plant community, percent change (%Δ) along the flow path was calculated using:

$$\%\Delta = \frac{C_{upstream} - C_{downstream}}{C_{upstream}} \times 100$$

Where $C_{upstream}$ and $C_{downstream}$ represent mean concentrations before and after passing through the plant stand. Positive values indicate improvement (reduction of EC or TDS, increase of DO), after passing through the plant stand. Positive values indicate improvement (reduction of EC or TDS, increase of DO), whereas negative values indicate deterioration.

4. Results

The physicochemical characteristics of water along the natural flow system showed clear spatial and seasonal variations among the three aquatic plant communities (*Utricularia aurea*, *Nelumbo nucifera*, and *Limnocharis flava*). Mean values, standard deviations, and ranges of dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), water temperature, and pH for each plant reach and sampling zone are summarized in Tables

4.1 Descriptive ranges across all observations

Indicator	Range (min–max)	Unit
DO	5.5–9.5	mg/L
EC	89–210	µS/cm
TDS	27–104	mg/L
Temperature	26.0–28.5	°C
pH	5.15–7.78	

Table 4.1. Overall observed ranges of water quality indicators across all sites, zones, and months (N = 27). Across all seasons, DO values ranged from moderately low to well-oxygenated conditions (5.5–9.5 mg L^{-1}), indicating generally healthy aerobic environments. EC and TDS exhibited wider variability, particularly within the reach dominated by *Limnocharis flava*, suggesting stronger interactions between water flow, sediments, and dissolved ions in emergent macrophyte zones. Water temperature showed seasonal patterns, with the highest values during the early rainy season and the lowest during the cool–dry season, while pH remained within a slightly acidic to neutral range (5.1–7.8), reflecting good buffering capacity of the system.

4.2 Comparison among Plant Communities (One-way ANOVA)

Variable	F	p-value	Significance (α=0.05)	Interpretation
DO	0.632	0.540	No	No evidence of differences among plant communities
EC	4.812	0.017	Yes	Plant community is associated with different conductivity levels
TDS	5.113	0.014	Yes	Plant community is associated with different dissolved solids levels
Temperature	6.117	0.007	Yes	Plant community is associated with different thermal regimes
pH	0.178	0.838	No	No evidence of differences among plant communities

Table 4.2. One-way ANOVA revealed that plant community type had a statistically significant effect on several water quality variables **Electrical Conductivity (EC):** Significant differences among plant communities ($F = 4.812$, $p = 0.017$). **Total Dissolved Solids (TDS):** Significant differences among plant communities ($F = 5.113$, $p = 0.014$). **Water Temperature:** Highly significant differences ($F = 6.117$, $p = 0.007$). **Dissolved Oxygen (DO):** No significant difference ($F = 0.632$, $p = 0.540$). **pH:** No significant difference ($F = 0.178$, $p = 0.838$).

These results indicate that the type of aquatic vegetation significantly influenced the ionic composition and thermal regime of the water, whereas DO and pH were relatively stable along the flow path and did not differ significantly among plant reaches.

4.3 Pairwise differences (Bonferroni post hoc)

Variable	Pair with significant difference	Mean difference	p-value
EC	Leafy Bladderwort vs Yellow Velvet Leaf	-37.67	0.048
EC	Lotus vs Yellow Velvet Leaf	-40.33	0.032
TDS	Leafy Bladderwort vs Yellow Velvet Leaf	-18.00	0.012
Temperature	Leafy Bladderwort vs Yellow Velvet Leaf	-0.88	0.006

Table 4.3. Bonferroni post hoc tests identified that:

EC and TDS in the *Limnocharis flava* reach were significantly higher than those in the *Utricularia aurea* and *Nelumbo nucifera* reaches ($p < 0.05$).

Water temperature in the *Limnocharis flava* reach was significantly higher than in the *Utricularia aurea* reach ($p < 0.01$).

No significant pairwise differences were detected for DO and pH among the three plant communities.

These findings suggest that submerged and floating-leaved plant communities were more effective in maintaining lower dissolved ion concentrations and cooler water temperatures compared with the emergent macrophyte-dominated reach.

Figures

Figure 4.1. Boxplot of dissolved oxygen (DO) by plant reach (n = 9 per reach).

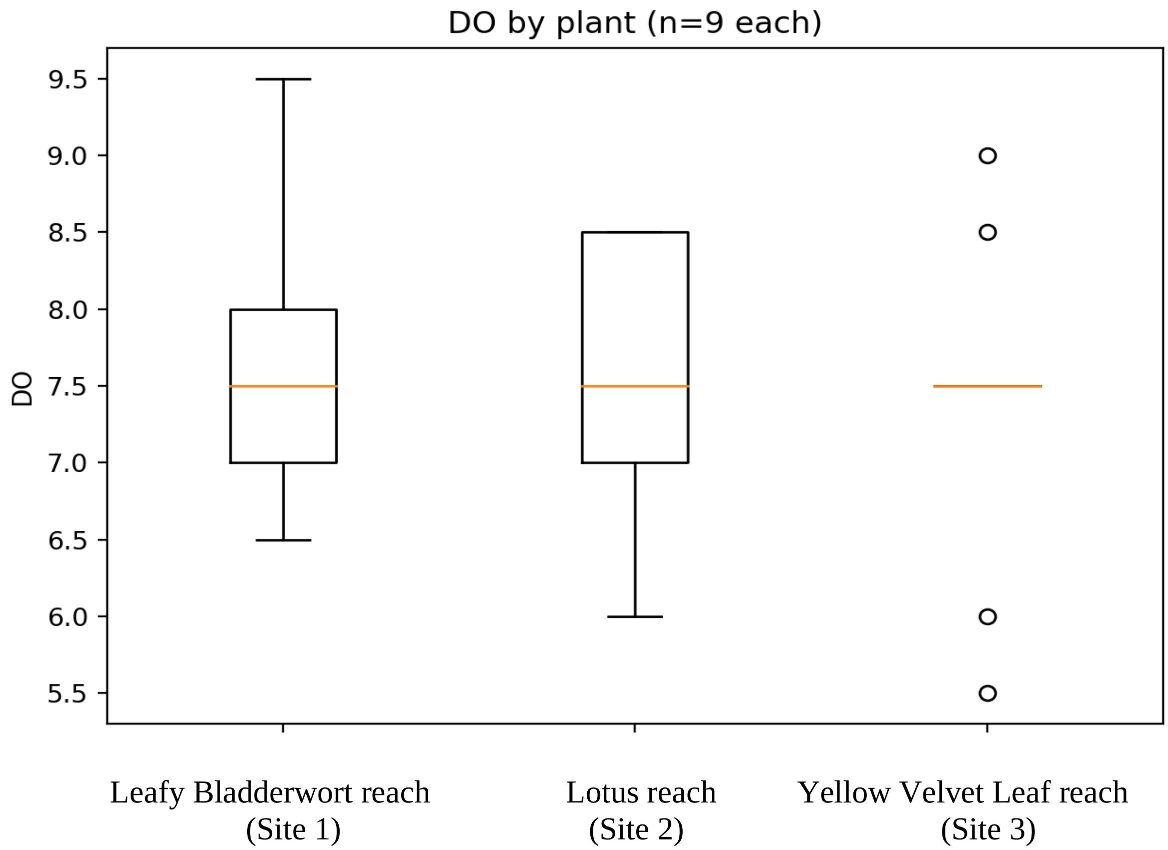


Figure 4.2. Boxplot of electrical conductivity (EC) by plant reach (n = 9 per reach).

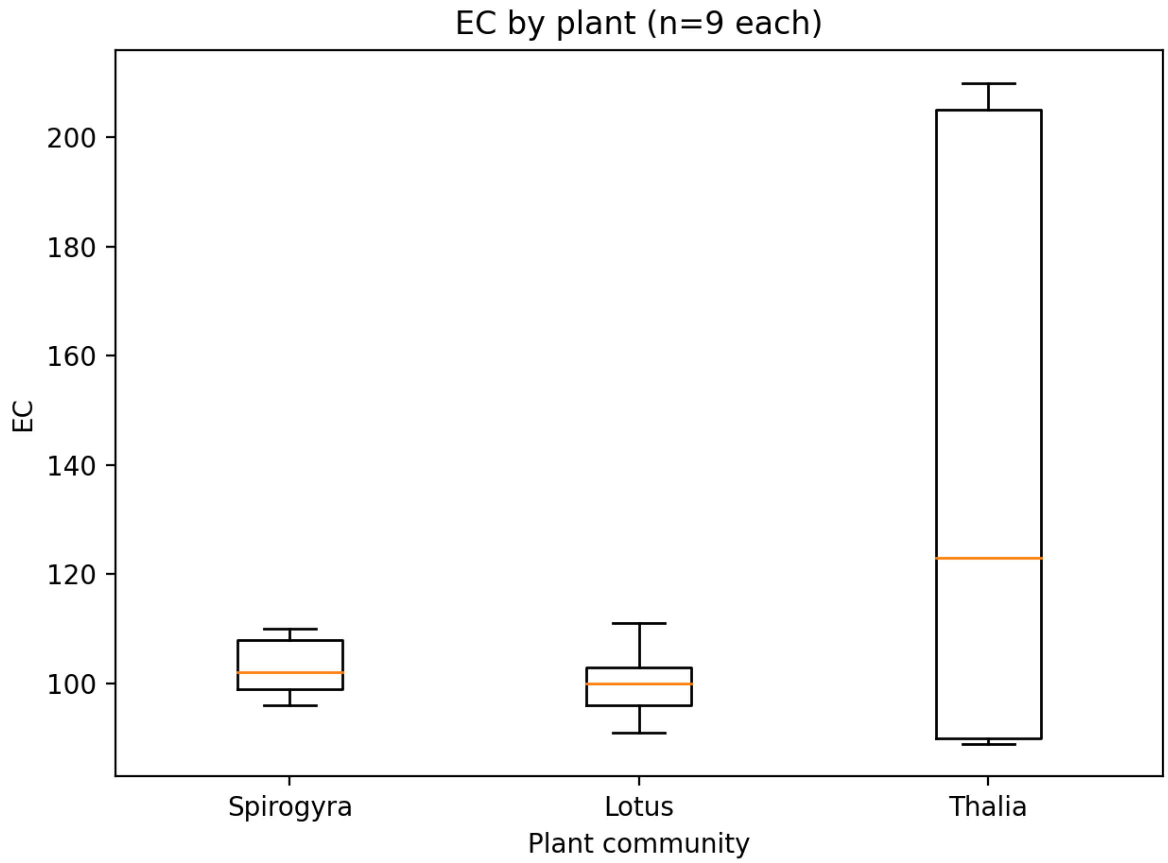


Figure 4.3. Boxplot of total dissolved solids (TDS) by plant reach (n = 9 per reach).

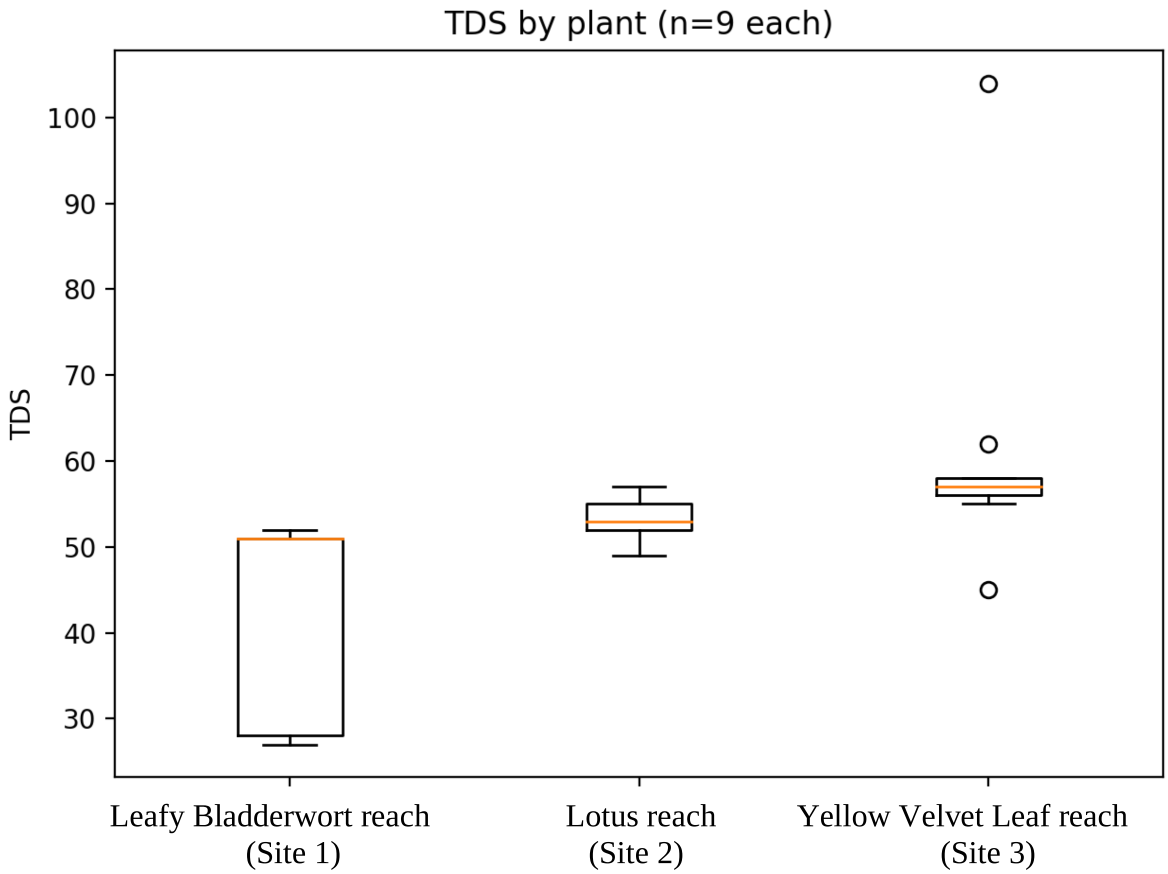


Figure 4.4. Boxplot of water temperature by plant reach (n = 9 per reach).

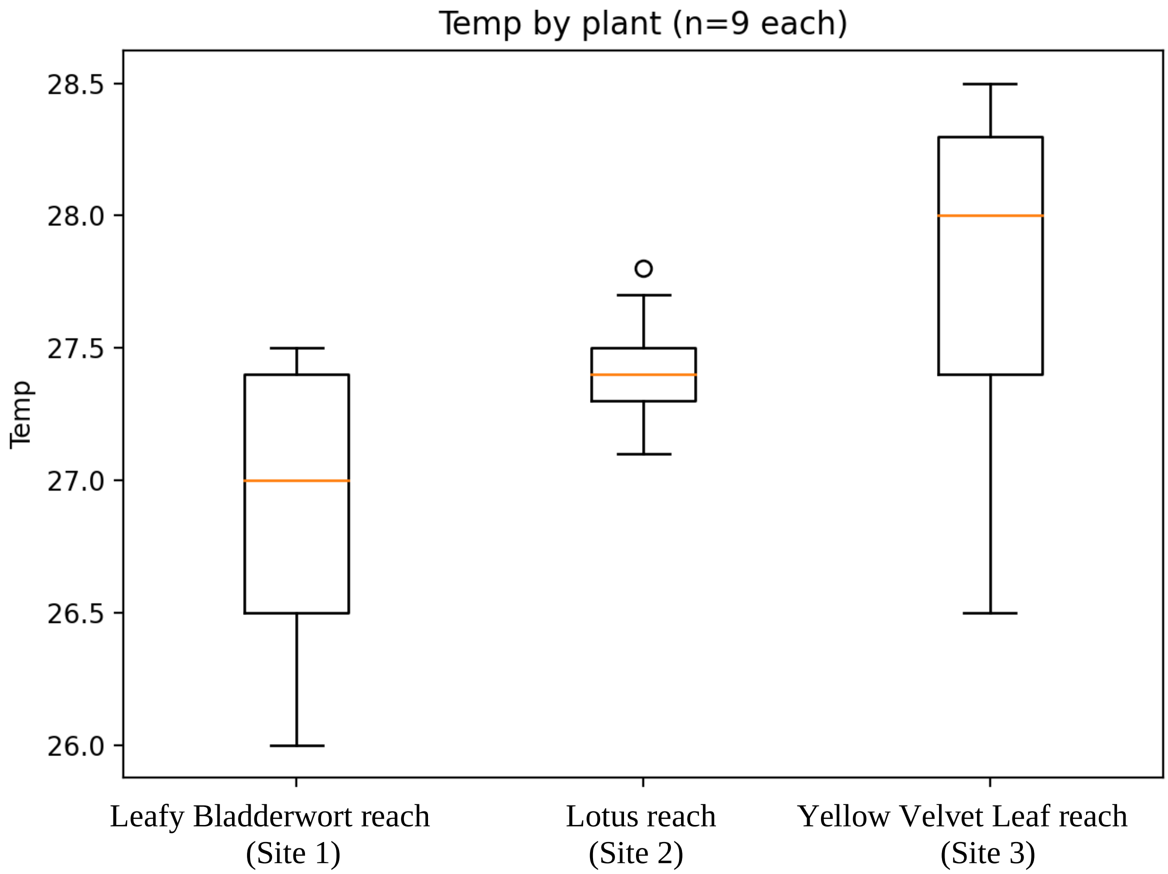


Figure 4.5. Boxplot of pH by plant reach (n = 9 per reach).

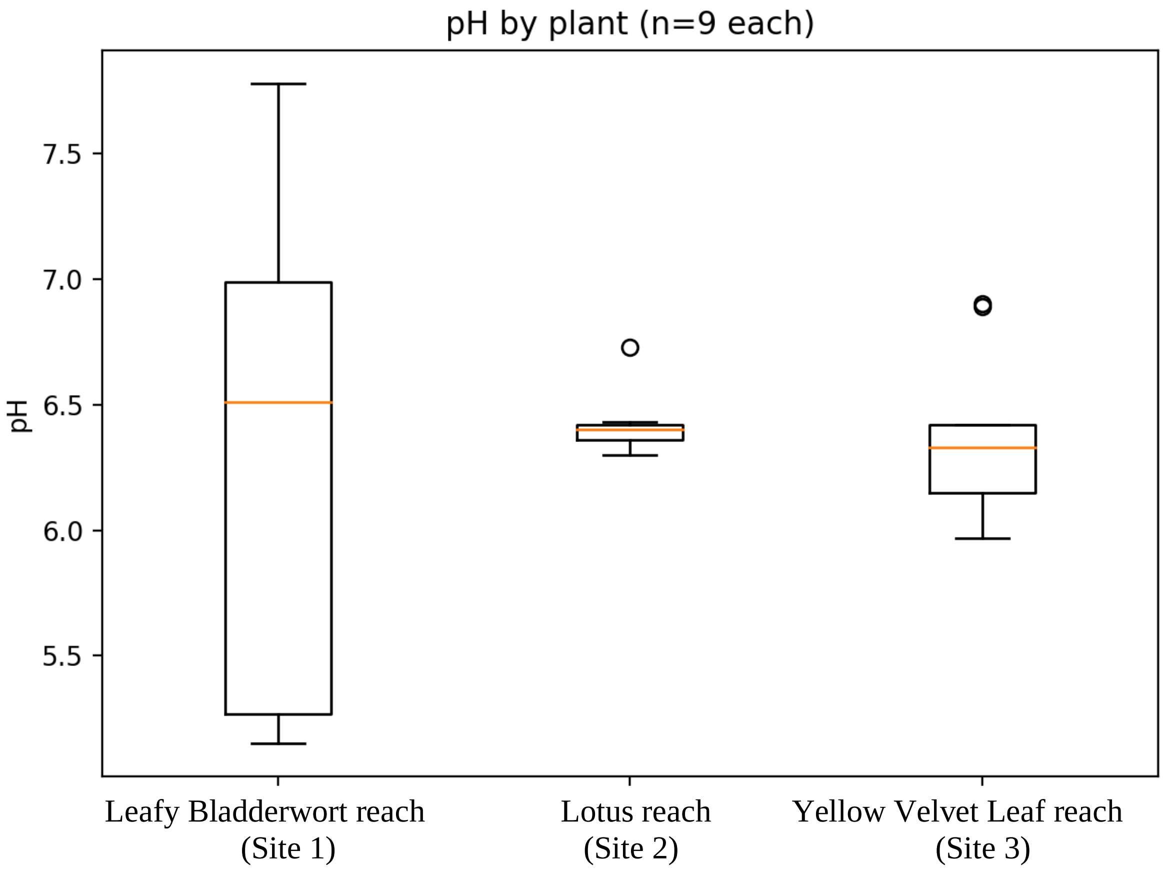


Figure 4.6. EC profiles from upstream to downstream zones for each plant reach across months.

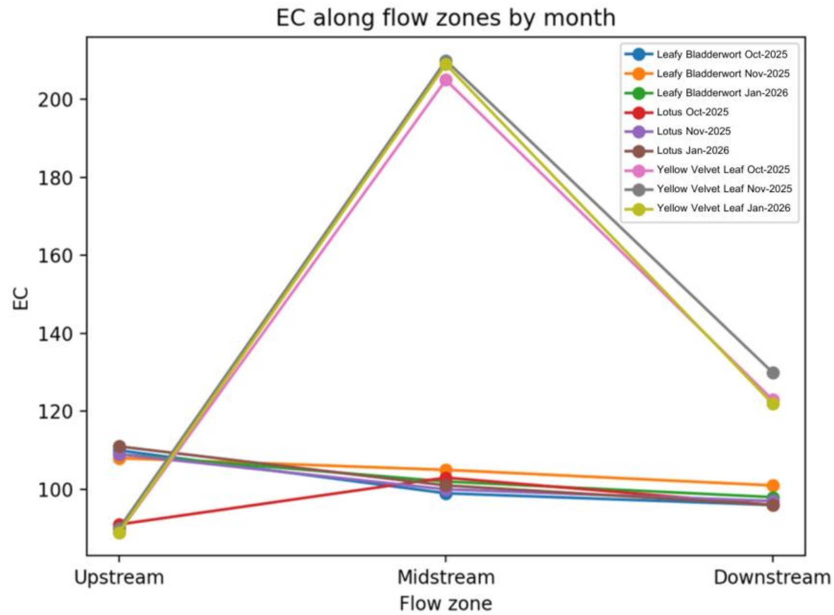


Figure 4.7. TDS profiles from upstream to downstream zones for each plant reach across months.

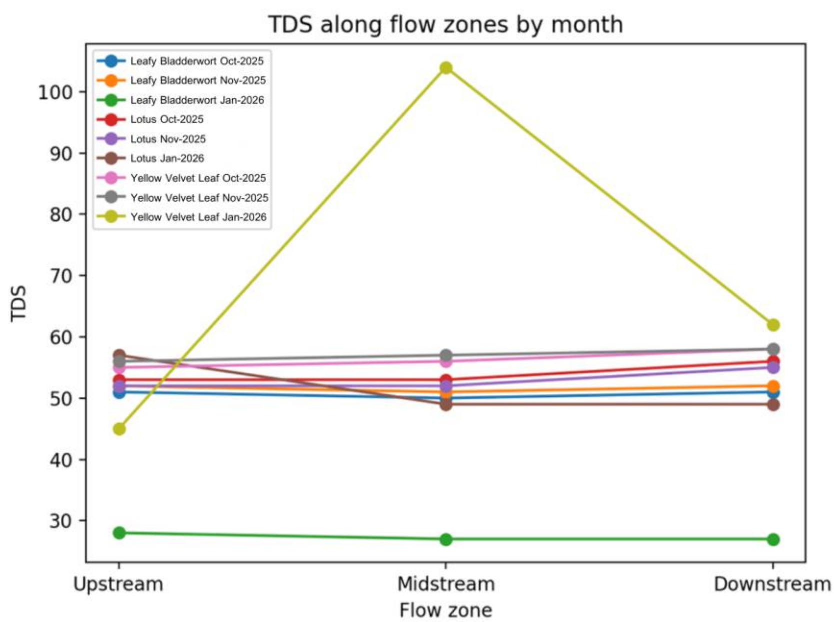
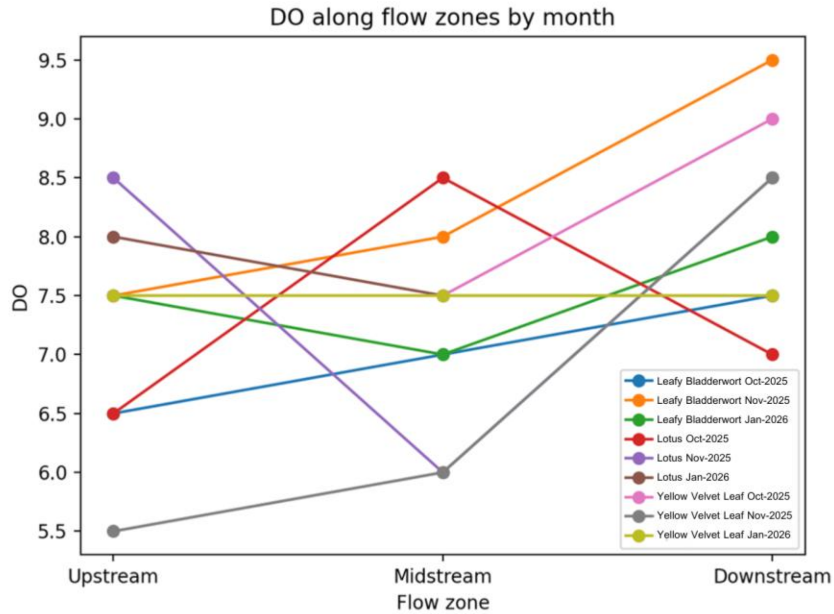


Figure 4.8. DO profiles from upstream to downstream zones for each plant reach across months.



5. Discussion

Significant differences among plant reaches were detected for EC, TDS, and temperature, indicating that plant community structure is associated with ion concentration, dissolved solids, and thermal conditions along the flow system. The Yellow Velvet Leaf reach consistently showed higher EC and TDS than the Leafy Bladderwort and lotus reaches, suggesting greater accumulation or release of dissolved ions/solids within this emergent macrophyte reach. This pattern may reflect slower flow, enhanced sediment–water interactions, and organic matter leaching from rhizosphere processes in densely rooted zones, which can elevate conductivity and dissolved solids. Conversely, the Leafy Bladderwort reach showed comparatively lower EC/TDS, consistent with the biofiltration role of filamentous algae mats that can adsorb and physically trap fine particles and associated ions.

DO and pH did not differ significantly among reaches, implying that aeration, mixing, and buffering processes at the channel scale may stabilize these indicators despite local plant differences. Seasonality likely modulated the magnitude of changes, particularly during the flood period, but the plant-associated contrasts in EC/TDS remained evident in the aggregated analysis.

6. Conclusion and Recommendations

This study demonstrates that different aquatic plant communities along a connected campus flow system can be associated with significantly different conductivity, dissolved solids, and temperature regimes. Among the three reaches, the Leafy Bladderwort and lotus reaches were generally linked to lower EC/TDS, whereas the Yellow Velvet Leaf reach showed elevated EC/TDS and warmer conditions. For nature-based water quality improvement on campus, prioritizing algae-dominated or lotus-dominated reaches (or the functional traits they represent) may be beneficial when the goal is to reduce dissolved ions/solids. Future work should (i) add nutrient indicators (NO_3^-, PO_4^{3-}, NH_3/NH_4^+), turbidity/TSS, and chlorophyll-a, (ii) increase sampling frequency and replication, (iii) measure flow rate and water depth to control hydrologic effects, and (iv) test pilot bio-filter panels made from local plant fibers to link field ecology to engineered filtration.

7. Bibliography (selected examples)

Wang, J., et al. (2021). Constructed wetland system integrated with aquatic macrophytes for cleaning storm/runoff water. Journal of Environmental Management.

Seymour, E. (2009). Assessing Lotus for Wastewater Bioremediation. RIRDC Publication No. 09/089.

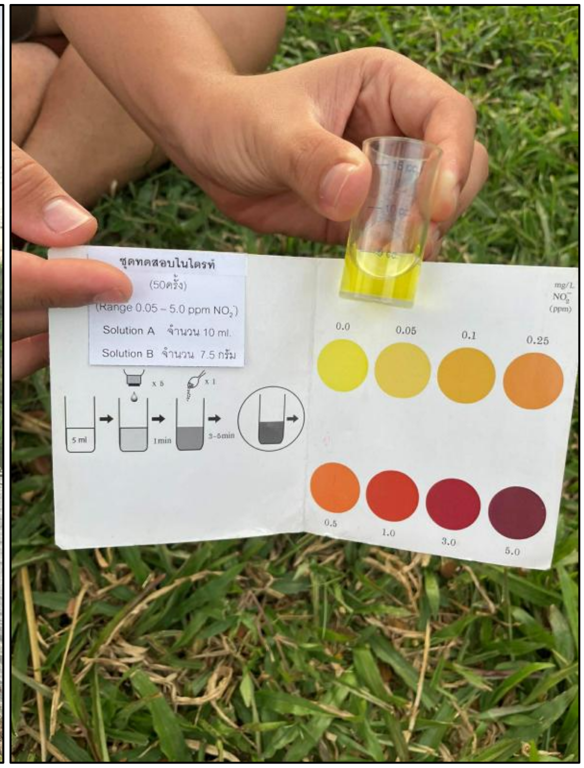
Vergara-Flórez, V., et al. (2023). Treatment wetland with Yellow Velvet Leaf geniculata for wastewater depuration. Processes, 11(9), 2754.

Rameshkumar, S., et al. (2019). Influence of physicochemical water quality on aquatic macrophytes. Applied Water Science, 9, 32.

Appendix


DISSOLVED OXYGEN EVALUATION CHART


AQUA-VRC
Ammonium
NH4


ชุดทดสอบไนไตรท์
(50ครั้ง)
(Range 0.05 – 5.0 ppm NO2-)
Solution A จำนวน 10 ml.
Solution B จำนวน 7.5 กรัม
x 5
x 1
5 ml
1min
3-5min
mg/L
NO2-
(ppm)
0.0
0.05
0.1
0.25
0.5
1.0
3.0
5.0