Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(5): 1371 – 1385 (2025)
www.ejabf.journals.ekb.eg

Effects of Depth and Water Quality on Aquatic Plant Distribution in Nong Han Lake, Sakon Nakhon Province: The Largest Freshwater Lake in Northeastern Thailand

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ARTICLE INFO

Article History:
Received: Jan. 27, 2025
Accepted: Sep. 10, 2025
Online: Sep. 27, 2025

Keywords:
Water depth,
Water quality,
Aquatic plant,
Nong Han Lake,
Sakon Nakhon Province

ABSTRACT

A study on the effects of depth and water quality on aquatic plant distribution in Nong Han Lake, Sakon Nakhon Province, Thailand, was conducted by surveying species diversity and biomass of aquatic plants along with physical and chemical parameters across 43 sampling stations. The survey was carried out during early dry season 2020, late dry season 2021, early rainy season 2021, and late rainy season 2021. The year-round survey revealed a total of 61 species from 30 families, with emergent plants being the dominant group. The most frequently encountered species across all seasons was the curly pondweed (*Potamogeton crispus* L.). Cluster analysis categorized the sampling stations into three groups based on water depth. A highly significant negative correlation (P<0.01) was found between water depth and species richness, while no correlation was observed between depth and aquatic plant biomass. Water quality in Nong Han Lake was generally good, except for some areas during the rainy season where water quality deteriorated. The findings indicate that Nong Han Lake has potential as an appropriate primary production source in the aquatic ecosystem. However, problems arising from dense aquatic plant distribution can lead to water body deterioration, particularly in littoral zones where plant debris accumulation may result in shallow, stagnant, and deteriorated conditions. Therefore, measures should be implemented to reduce nutrient loading into the water body and to optimize the harvesting of aquatic plants for maximum utilization.

INTRODUCTION

Aquatic plants are vital natural resources in aquatic ecosystems, serving multiple functions including primary production, food sources, aquatic animal habitats, sediment and pollutant filtration, nutrient cycling, and human utilization **(Dibble *et al.*, 1996; Bornette & Puijalon, 2009; Quirino *et al.*, 2022)**. The abundance of aquatic plants in water bodies reflects nutrient richness and indicates the status of these aquatic environments **(Søndergaard *et al.*, 2013; O'Hare *et al.*, 2018)**. Furthermore, aquatic plants play a crucial role in carbon sequestration within aquatic ecosystems in the context of climate change **(Reitsema *et al*., 2018)**. Physical characteristics of water bodies are key factors in aquatic plant growth, including water depth, turbidity and sediment, light penetration to the bottom, and water mass movement **(Dar *et al*., 2014; Kading & Xu, 2021)**. Water depth, in particular, is a critical factor affecting the distribution of submerged aquatic plants, as decreased water levels result in increased light intensity, subsequently affecting biomass and species diversity **(Chambers & Kaiff, 1985; Middelboe & Markager, 1997; Beklioglu *et al*., 2006)**.

Nong Han Lake in Sakon Nakhon Province is the largest freshwater lake in northeastern Thailand, covering an area of 123 square kilometers. It has been utilized in various ways and has been integral to local livelihoods from past to present **(Sukthanapirat *et al*., 2017)**. The physical characteristics of the lake have transformed from its natural state as a seasonal floodplain to a semi-closed water body following the construction of the water gate, which now controls water levels within the lake. Urban expansion and agricultural activities around Nong Han Lake have resulted in continuous nutrient loading through wastewater discharge **(Settacharnwit *et al*., 2003)**. Consequently, aquatic plants have rapidly proliferated, particularly in littoral zones where aquatic plants and weeds grow, die, and accumulate over extensive areas. The increased abundance of aquatic plants can lead to various problems such as water flow obstruction, sedimentation, and water quality deterioration due to organic matter decomposition **(Ismail *et al*., 2019; Verhofstad & Bakker, 2019)**. Without proper management of aquatic plants, adverse effects on the aquatic ecosystem could impact other living organisms.

This research aimed to study the influence of water depth and environmental factors on seasonal changes in aquatic plant species composition, abundance, and succession. Geographic Information Systems (GIS) were employed to clearly visualize spatial research data, facilitating the development of aquatic plant management strategies for utilization and control of proliferating aquatic vegetation appropriate to the area's physical characteristics. The findings from this study can contribute to policy development for sustainable utilization and conservation of natural resources in the lake.

MATERIALS AND METHODS

1. Study area

The study of aquatic plant resources was conducted in Nong Han Lake, covering areas in Mueang and Phon Na Kaew Districts, Sakon Nakhon Province, across 43 sampling stations (Fig. 1). The research employed a line transect sampling design, establishing 13 transect lines distributed throughout the lake. Surveys were conducted during early dry season 2020, late dry season 2021, early rainy season 2021 and late rainy season 2021.

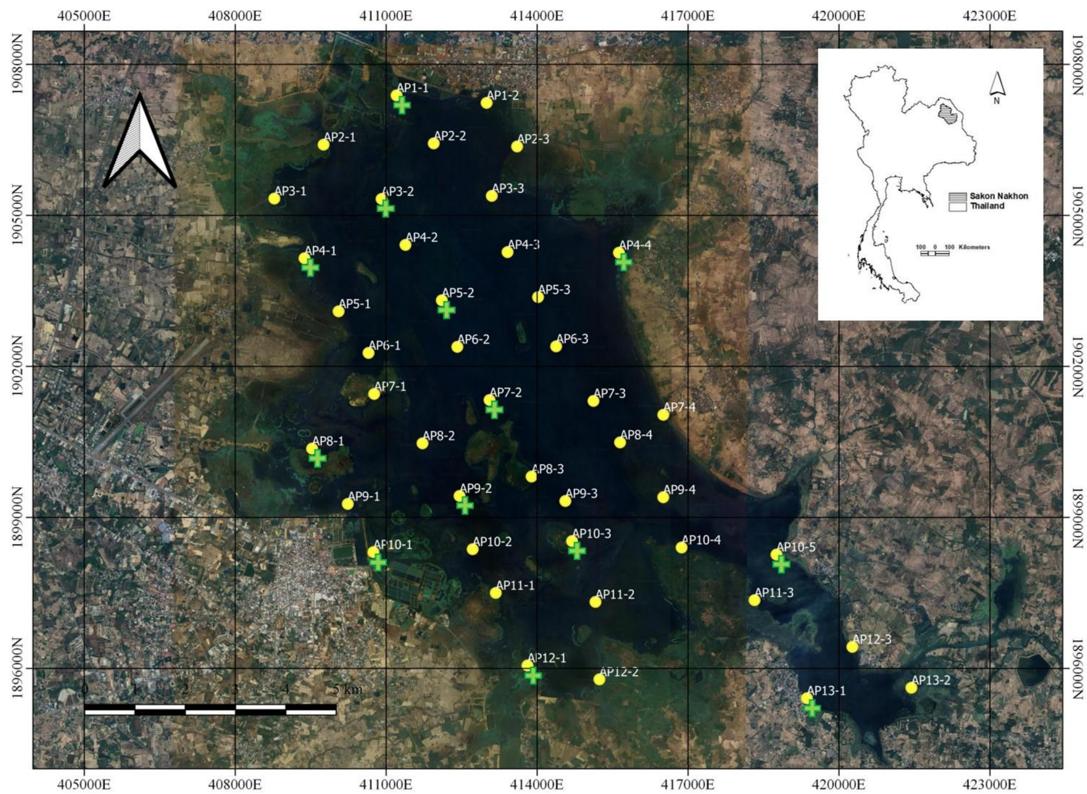


Fig. 1. Aquatic plant sampling stations in Nong Han Lake study area, Sakon Nakhon Province, Thailand

(Note: Stations marked with green crosses indicate locations where aquatic plant samples were collected for biomass studies).

2. Physical and chemical characteristics of Nong Han Lake water

Water depth was measured from 43 sampling points distributed across the entire area of the lake, using a Hondex PS-7 depth meter for accurate measurements over four periods (early dry season 2020, late dry season 2021, early rainy season 2021 and late rainy season 2021). the Inverse Distance Weighting (IDW) interpolation technique in QGIS open-source software version 3.10.4 was employed to estimate a continuous surface representation in the bathymetric map.

Water quality parameters were measured at 0-50 centimeters depth at the same locations as aquatic plant sampling. Parameters included water temperature, electro-conductivity, salinity, pH, dissolved oxygen, and total dissolved solids, measured using a YSI Professional Plus Multiparameter Probe. Water transparency was measured using a Secchi disk. Secondary data were obtained from surface water quality reports during 2020-2021 by the **Environment and Pollution Control Office 9 Udon Thani (2020, 2021)**.

3. Aquatic plant distribution

The aquatic plant survey in Nong Han Lake employed a line transect survey method, establishing 13 transect lines covering the entire water body. Sampling points were established approximately 1,000 meters apart along each transect line. The frequency of occurrence for each plant species was calculated using the formula:

Percentage frequency = (Number of occurrences of the species × 100) / Total number of surveys

Aquatic plant samples were collected from within 1-square meter quadrats at 13 sampling stations. Wet weight was measured to determine biomass per unit area. Plant specimens were identified through comparison with herbarium specimens at the Queen Sirikit Botanic Garden, and verified using local flora documentation **(Worayot, 1994; Sripen, 2000; Fassett, 2006; Rodloy *et al*., 2012)**.

4. Data analysis

Data were presented using descriptive statistics. Group comparisons were conducted using t-test and One-way ANOVA. The relationships between aquatic plants and environmental factors were analyzed using Spearman's rank correlation coefficient. Data clustering was performed using Cluster analysis **(Clarke & Warwick, 1994)**.

RESULTS

1. Physical and chemical characteristics of Nong Han Lake water

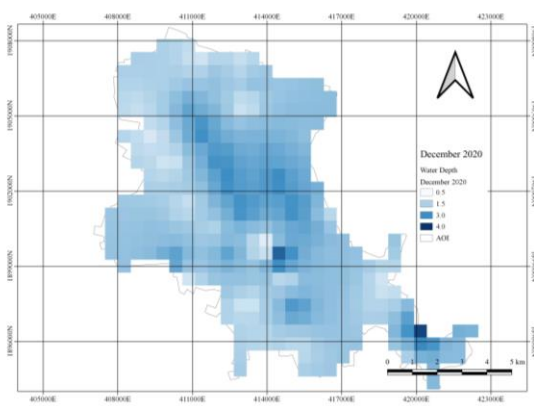
1.1 Morphology of the study area

The physical characteristics of different areas in Nong Han Lake vary considerably, comprising terrestrial-aquatic transition zones along the shoreline, open water areas, islands of varying sizes with diverse soil types, and tributary connection zones. Fig. (2) illustrates water depth variations at sampling stations across different seasons. During early dry season 2020, water depth ranged from 0.4-4.0 meters with a mean of 2.0±0.8 meters. In late dry season 2021, depths ranged from 0.3-3.2 meters with a mean of 1.6±0.8 meters. Early rainy season 2021 showed depths between 0.3-3.1 meters with a mean of 1.3±0.7 meters, while late rainy season 2021 recorded depths of 0.6-4.1 meters with a mean of 2.4±0.8 meters. The data indicate higher water levels during flood seasons compared to other periods. Statistical analysis revealed highly significant seasonal differences in water depth (P<0.01).

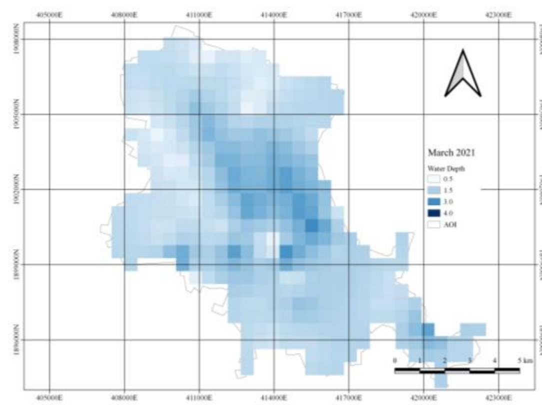
The morphological characteristics of Nong Han Lake present a basin structure with a gradient sloping from west to east, ultimately draining into Nam Kam River.

Consequently, areas along the eastern edge, particularly the southeastern region, maintain considerable depth throughout the year. In contrast, the western shore is relatively shallow, with several areas becoming exposed during the dry season. This morphological configuration and orientation allow for optimal sun exposure throughout the year. The high water transparency enables sufficient light penetration at all depths. These physical characteristics have contributed to lake's long-standing dense aquatic vegetation **(Scheffer *et al*., 1993)**.

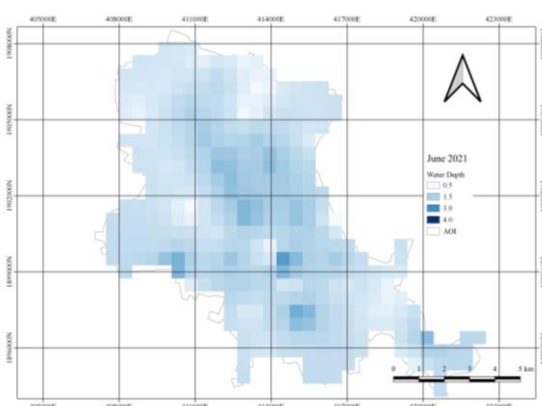
Seasonal water level fluctuations affected the shorelines of various islands scattered throughout the lake, resulting in uneven inundation patterns across seasons. Consequently, surveys and sampling at identical geographical coordinates during different periods revealed varying site characteristics.



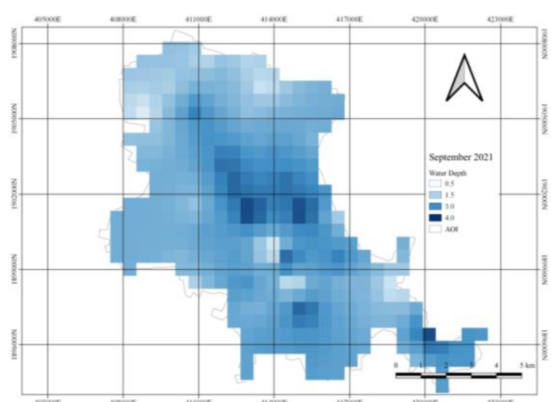
Early dry season 2020



Late dry season 2021



Early rainy season 2021



Late rainy season 2021

Fig. 2. Water depth in Nong Han Lake across different seasons

1.2 Water quality

Water temperature showed significant seasonal variation (*P*<0.01). During early dry season 2020 (winter period), the mean water temperature was only 23.3°C. Late dry season 2021 exhibited higher temperatures (23.1-34.3°C, mean 27.1°C). Early rainy season 2021, despite frequent rainfall, recorded high water temperatures (mean 29.9°C), similar to late rainy season 2021, which maintained high temperatures during clear survey days (mean 29.4°C). These temperature fluctuations followed normal daily air temperature patterns, allowing plants to adapt without significant stress. The annual temperature range remained suitable for tropical aquatic plant growth of all types **(Srivastava *et al*., 2008)**.

Dissolved oxygen levels during early dry season 2020 ranged from 3.45-7.94mg/L (mean 6.10mg/ L), late dry season 2021 from 2.93- 11.50mg/ L (mean 6.53mg/ L), and early rainy season 2021 from 0.83- 7.66mg/ L (mean 4.64mg/ L). The rainy season showed notably lower values due to flood-induced sediment runoff, bottom sediment disturbance in shallow areas, and reduced photosynthetic activity during cloudy periods. High aquatic plant biomass can cause significant diurnal oxygen fluctuations, potentially affecting aquatic fauna **(Petr, 2000)**. No significant seasonal differences in dissolved oxygen levels were observed. pH values ranged from 7.06-8.96 (mean 8.01) in early dry season 2020, 6.88-10.26 (mean 8.33) in late dry season 2021, 6.81-9.85 (mean 8.14) in early rainy season 2021, and 6.53-9.55 (mean 8.19) in late rainy season 2021. These values indicate slightly alkaline conditions, with late dry season showing higher values, exceeding 9.00 in several stations. Many aquatic plants, such as pondweed and coontail, tolerate alkaline conditions well. A positive correlation was observed between dissolved oxygen and pH, reflecting photosynthetic activity, respiration, and redox reactions in the water **(Zang *et al.*, 2011)**.

Water transparency exceeded water depth at most stations, except in areas affected by suspended particles. The Secchi depth indicated light penetration above 1%, sufficient for photosynthesis in the euphotic zone **(Luhtala & Tolvanen, 2013)**. Electro-conductivity (80.5- 438.2µS/ cm, mean 171.9±58.0), total dissolved solids (17.9-266.5mg/ L, mean 106.2±36.4), and salinity (0.03- 0.19ppt, mean 0.08±0.02) remained relatively low across all seasons. Late dry season showed slightly higher concentrations due to evaporation, but values remained within freshwater standards suitable for aquatic plant life. **Hallock and Hallock (1993)** reported TDS impact thresholds of 1,170mg/ L for *Ceratophyllum demersum* and *Typha* sp., while **Moreira *et al*. (2023)** noted freshwater plants generally tolerate salinity up to 5 ppt. Secondary data from the **Environment and Pollution Control Office 9 Udon Thani (2020, 2021)** showed turbidity ranging from 0-168 NTU, suspended solids <10-23 mg/L, ammonia-nitrogen nd-0.12mg/ L, and total phosphorus 0.005- 1.29mg/ L. Overall water quality was good, except for some stations during rainy seasons, particularly near Sakon Nakhon Municipality wastewater treatment plant.

2. Aquatic plant diversity

The survey across 43 stations in Nong Han Lake revealed 61 species from 30 families. Early dry season 2020 yielded 52 species from 27 families, late dry season 2021 showed 46 species from 27 families, early rainy season 2021 recorded 50 species from 27 families, and late rainy season 2021 found 48 species from 28 families. Details of all aquatic plants found in Nong Han Lake are presented in Table (1).

Table 1. Aquatic plants found in Nong Han Lake, Sakon Nakhon Province, during early dry season 2020, late dry season 2021, early rainy season 2021 and late rainy season 2021

No.	Scientific name	Common name	Type*	Early dry season 20	Late dry season 21	Early rainy season 21	Late rainy season 21
1.	*Alternanthera philoxeroides* (Mart.) Griseb.	Alligator weed	E	+	+	+	-
2.	*Hydrocotyle umbellata* L.	Water pennywort	E	+	+	+	+
3.	*Centella asiatica* L.	Asiatic pennywort	E	+	+	+	+
4.	*Eclipta prostrata* L.	False Daisy	E	+	-	+	+
5.	*Vernonia cinerea* (L.) Less.	Little iron weed	E	+	-	-	-
6.	*Neptunia oleracea* Lour.	Neptunia	FF	+	+	+	+
7.	*Mimosa pigra* L.	Giant mimosa	E	+	+	+	+
8.	*Phaseolus lathyroides* L.	Scarlet bean	E	+	+	-	-
9.	*Heliotropium indicum* L.	Indian heliotrope	E	-	+	-	-
10.	*Ipomoea aquatica* Forssk.	Water morning glory	FF	+	+	+	+
11.	*Nymphoides parvifolia* (Wall.) O. Kuntze	Water snowflake	FF	+	+	+	+
12.	*Utricularia aurea* Lour.	Common bladderwort	S	+	+	+	+
13.	*Nymphaea lotus* L.	Water lily	FL	+	+	+	+
14.	*Nymphaea stellata* Willd.	Water lily	FL	+	-	-	-
15.	*Nelumbo nucifera* Gaertn.	Lotus	FL	+	+	+	+
16.	*Ludwigia adscendens* (L.) Hara	Water primrose	E	+	+	+	+
17.	*Polygonum tomentosum* Wild.	Knotweed	E	+	+	+	+
18.	*Salix tetrasperma* Roxb.	Indian willow	E	+	+	+	+
19.	*Trapa incisa* Siebold & Zucc.	Water chestnut	FF	+	+	+	+
20.	*Pistia stratiotes* L.	Water lettuce	FF	+	+	+	+
21.	*Colocasia esculenta* (L.) Schott	Wild taro	E	+	+	+	+
22.	*Limnocharis flava* (L.) Buch.	Yellow Velvetleaf	E	+	+	+	+
23.	*Ceratophyllum demersum* L.	Coontail	S	+	+	+	+
24.	*Cyperus difformis* L.	Small-flowered umbrella sedge	E	+	-	+	-
25.	*Cyperus cephalotes* Vahl	Flatsedge	E	+	+	+	+
26.	*Cyperus tenuispica* Steud.	Slender spiked sedge	E	+	+	+	-
27.	*Cyperus pulcherrimus* Willd. ex Kunth	Elegant cyperus	E	+	+	+	+

No.	Scientific name	Common name	Type*	Early dry season 20	Late dry season 21	Early rainy season 21	Late rainy season 21
28.	*Cyperus pilosus* Vahl.	Hairy cyperus	E	+	+	+	+
29.	*Cyperus digitatus* Roxb.	Finger flatsedge	E	+	-	-	+
30.	*Cyperus platystylis* R. Br.	Platystylis sedge	E	+	+	+	+
31.	*Cyperus iria* L.	Rice flatsedge	E	-	-	+	-
32.	*Scirpus grossus* (L.f.)	Greater club rush	E	+	+	+	+
33.	*Fimbristylis globulosa* (Retz.) Kunth.	Lesser fimbristylis	E	+	-	+	+
34.	*Fimbristylis miliacea* (L.) Vahl.	Globe fringerush	E	+	-	-	-
35.	*Eleocharis dulcis* (Burm.F.) Hensch.	Spike rush	E	+	+	+	+
36.	*Vallisneria gigantea* Graebn.	Tapegrass	S	+	+	+	+
37.	*Hydrilla verticillata* (L.f.) Royle	Hydrilla	S	+	+	+	+
38.	*Hydrocharis dubia* (Bl.) Back.	Frogbit	FF	-	+	+	+
39.	*Lemna perpusilla* Torr.	Duckweed	FF	-	+	+	-
40.	*Spirodela polyrhiza* L.	Greater duckweed	FF	-	+	+	+
41.	*Wolffia arrhiza* (L.) Horkel ex Wimm.	Water meal	FF	-	-	-	+
42.	*Najas graminea* Del.	Bushy pondweed	S	+	+	+	+
43.	*Brachiaria mutica* (Forssk.) Stapf.	Scotch grass	E	+	+	+	+
44.	*Imperata cylindrica* (L.) P. Beauv.	Cogon grass	E	+	+	+	+
45.	*Leersia hexandra* Swog	Southern cutgrass	E	+	+	+	+
46.	*Isachne globosa* (Thunb.) Kuntze	Swamp millet	E	+	+	+	+
47.	*Paspalum vaginatum* Sw.	Swamp couch	E	-	+	+	-
48.	*Echinochloa colonum* (L.) Link.	Jungle rice	E	+	-	-	-
49.	*Leptochloa chinensis* (L.) Nees.	Chinese sprangletop	E	+	-	+	+
50.	*Hymenachne pseudointerrupta* C.Muell	Bamboo grass	E	-	-	-	+
51.	*Eichhornia crassipes* (Hart.) Solms	Water hyacinth	FF	+	+	+	+
52.	*Monochoria hastata* (L.) Solms	Monochoria	E	+	-	+	+
53.	*Potamogeton crispus* L.	Curly pondweed	S	+	+	+	+
54.	*Potamogeton malaianus* Miq.	Pondweed	S	+	+	+	+
55.	*Typha angustifolia* L.	Lesser reedmace	E	+	+	+	+
56.	*Pandanus* sp.	False pineapple	E	+	+	+	+
57.	*Diplazium esculentum* (Retz.) Sw.	Vegetable fern	E	+	+	+	+
58.	*Azolla pinnata* R. Br.	Water fern	FF	+	+	+	+
59.	*Marsilea crenata* Presl	Water clover	E	+	-	-	-
60.	*Ceratopteris thalictroides* Brongn	Horn fern	E	-	-	-	+
61.	*Salvinia cucullata* Roxb.	Floating moss	FF	+	+	+	+

* Classification of aquatic plants types according to their ecological habitat: E = Emergent plant, FF= Free-floating plant, FL = Floating-leaved plant and S = Submergent plant.

According to habitat and growth form classification **(Chamber *et al.*, 2007)**, aquatic plants were categorized into four types: free-floating plants, emergent plants, submergent plants, and floating-leaved plants. The study revealed that emergent plants showed the highest species diversity with 34, 26, 30, and 28 species, representing 65.38, 56.52, 60.00, and 58.33% of total species found during early dry season 2020, late dry season 2021, early rainy season 2021, and late rainy season 2021, respectively.

Dominant aquatic plants in Nong Han Lake included the curly pondweed (*Potamogeton crispus* L.) (frequency of occurrence: 93.02%, 95.35%, 86.05%, and 90.70% across the four seasons, respectively) (Fig. 3), the floating moss (*Salvinia cucullata* Roxb.) (frequency: 55.81%, 48.84%, 41.86%, and 55.81%), and water hyacinth (*Eichhornia crassipes* (Hart.) Solms) (frequency: 53.49%, 46.51%, 37.21%, and 41.86%). Other commonly found species included the coontail (*Ceratophyllum demersum* L.), the bushy pondweed *(Najas graminea* Del.), water primrose (*Ludwigia adscendens* (L.) Hara) and water lettuce (*Pistia stratiotes* L.). Secondary data analysis revealed that 81.97% of identified species have potential uses, including food, medicine, green manure, handicrafts, ornamental purposes, and wastewater treatment.

Fig. 3. Curly pondweed (*Potamogeton crispus* L.), the most dominant aquatic plant species in Nong Han Lake, Sakon Nakhon Province

Literature review findings align with this observation regarding biodiversity patterns, particularly the dominance of emergent plants and the prevalence of pondweed, water hyacinth and coontail as dominant species. Changes in aquatic plant community structure can occur due to spatial changes, hydrological characteristics, seasonal nutrient variations, and human activities. Some species may disappear seasonally, depending on their growth habits, life cycles, and distribution patterns **(Portielje & Roijackers, 1995; Ge *et al*., 2018)**.

3. Spatial distribution of aquatic plants

Aquatic plants were distributed throughout Nong Han Lake in both shallow and deep waters, with deeper areas typically located in the central and eastern portions. The central basin's open water characteristics favored rooted submerged plants, while free-floating plants were absent from central areas due to wind-driven accumulation along the shoreline. Consequently, stations with highest species diversity were typically located in shallow shoreline areas.

The highest species diversity was recorded at different stations across seasons: Station AP3-1 (25 species) and AP1-1 (22 species) in early dry season 2020; AP1-1 (22 species) and AP3-1 (20 species) in late dry season 2021; AP8-3 and AP10-3 (23 species each) and AP1-1 (21 species) in early rainy season 2021; and AP1-1 (24 species) and AP7-1 (21 species) in late rainy season 2021 (Fig. 4).

Stations with lowest diversity, featuring only curly pondweed, were consistently found in the eastern deep-water zone (stations AP3-2, AP4-2, AP4-3, AP5-2, AP5-3, AP6-2, AP6-3, AP7-2, AP7-3, AP8-4, AP9-2, AP9-3, AP9-4, and AP11-2) across all seasons. These stations had water depths of 2-4 meters. Lesiv *et al*. (2020) noted that aquatic plants typically inhabit depths of 0-4 meters where sufficient light enables photosynthesis. Floating-leaved plants like *Nelumbo nucifera* Gaertn., though typically found in shallow waters, can adapt to depths exceeding 3.5 meters by extending their petioles and flower stalks above water.

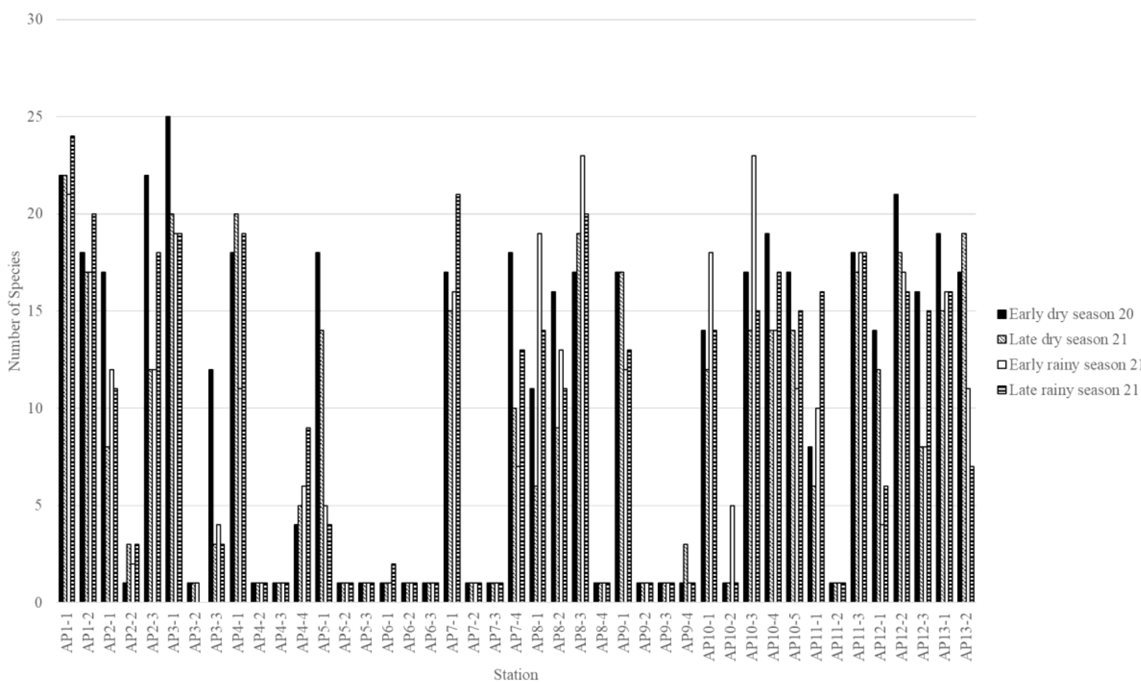


Fig. 4. Number of aquatic plant species found in Nong Han Lake, Sakon Nakhon Province, during early dry season 2020, late dry season 2021, early rainy season 2021 and late rainy season 2021

4. Influence of water depth on species richness and biomass

Cluster analysis of sampling stations based on water depth yielded three distinct groups: Group 1 (<1.3 m depth, 53 stations), Group 2 (1.3-2.5 m depth, 82 stations), and Group 3 (>2.5 m depth, 37 stations) (Fig. 5). Statistical analysis revealed highly significant differences in species richness among these depth groups ($\underline{P}<0.01$). Group 1 stations (<1.3 m) exhibited the highest average species richness (13.79±5.73 species), while Group 3 stations (>2.5 m) showed the lowest (3.60±5.45 species). Statistical analysis demonstrated a highly significant negative correlation between depth and species richness ($P<0.01$), following the linear equation y = -4.9121x + 18.15 (R^2 = 0.3067).

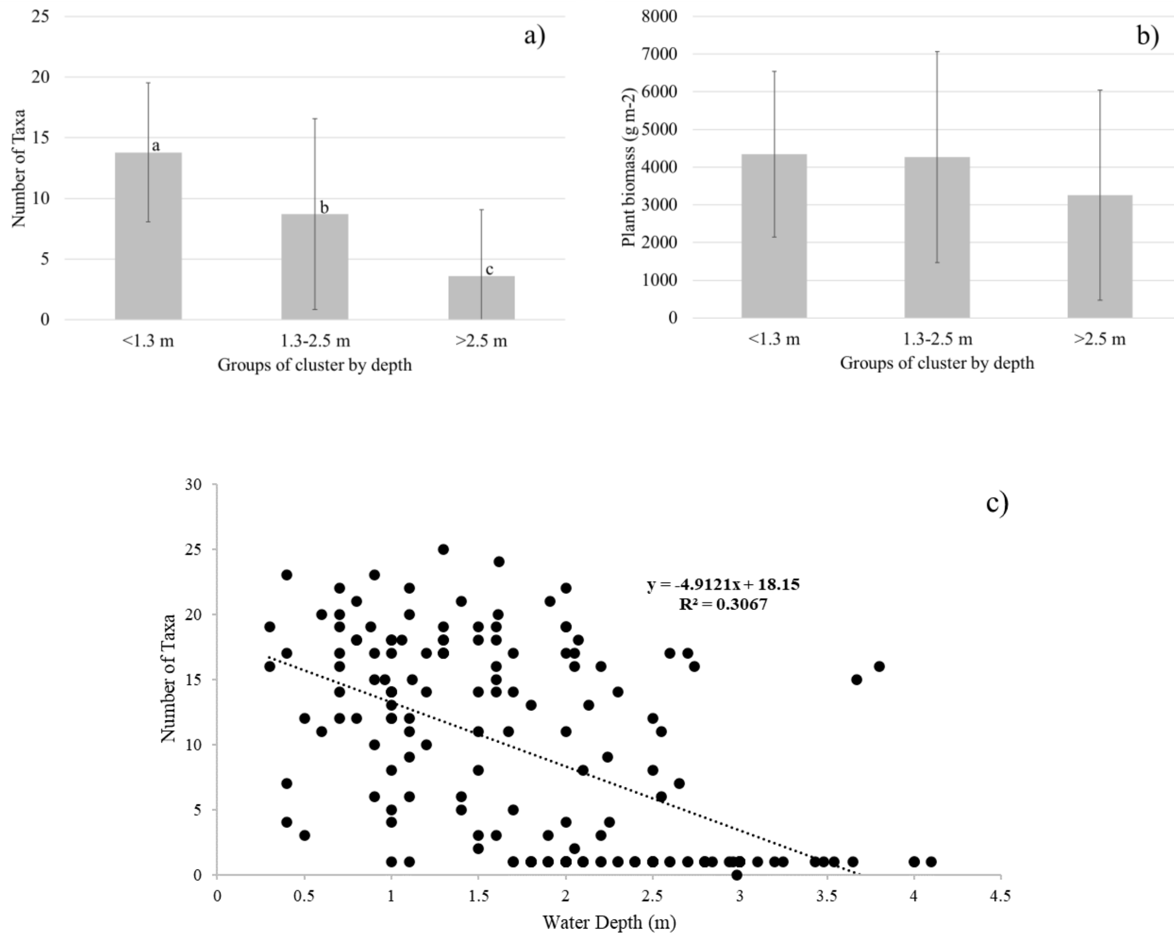


Fig. 5. (a) Number of aquatic plant taxa found, (b) aquatic plant biomass categorized by water depth groups, and (c) relationship between water depth and number of plant taxa

However, analysis of primary productivity or biomass showed no statistically significant differences (Fig. 5) either between stations or across seasons. This indicates that Nong Han Lake can sustain aquatic plant biomass across all areas and habitat types, regardless of water depth, with biomass comprising either single or multiple species. This contrasts with the study of **Li *et al*. (2021)**, who found lower biomass and plant density in deeper waters. They noted that increased water depth reduces underwater light intensity and inhibits the growth and distribution of submerged plants **(Ren *et al*., 2024)**. Therefore, the definition of "deep water" must consider light penetration to the bottom substrate.

Wu *et al*. (2021) observed that pondweed effectively adapts to low light intensity in deep waters and can survive in depths exceeding 5-7 meters with low light and temperature conditions **(Stuckey *et al*., 1978; Tobiessen & Snow, 1983)**. Consequently, given Nong Han Lake's depth profile and water transparency, pondweed can distribute throughout the entire lake system.

CONCLUSION

The physical characteristics of Nong Han Lake, Sakon Nakhon Province, as a semi-closed water body with relatively shallow average depth and sufficient light penetration to the bottom, facilitate aquatic plant distribution throughout both littoral and limnetic zones. The dominant species with the highest frequency was the curly pondweed (*Potamogeton crispus* L.), which demonstrates excellent adaptation to deeper waters. Other aquatic plant species were distributed along the shoreline, with emergent plants being the most abundant group. Water depth was found to be a limiting factor for species richness in different areas, although it did not affect plant biomass across different cluster groups. This indicates that Nong Han Lake serves as an appropriate primary production source in the aquatic ecosystem, supporting other resources in the food chain and functioning as an effective carbon sink to mitigate climate change.

However, problems arising from dense aquatic plant distribution can lead to both physical and chemical deterioration of the water body, affecting resident organisms. This is particularly evident in shoreline areas where plant debris accumulation can result in sedimentation and decomposition. While mechanical management of aquatic plants has been implemented continuously in Nong Han Lake, it has been limited in scope due to various constraints. Similarly, harvesting aquatic plants for utilization remains limited due to high transportation costs. Therefore, addressing the root cause through controlling waste and nutrient discharge into the water body from various activities, or implementing hydrological management techniques such as the drawdown technique during appropriate periods, may help reduce aquatic plant proliferation.

ACKNOWLEDGEMENTS

We express our gratitude to the Princess Sirindhorn Center for Sustainable Development and Kasetsart University Research and Development Institute for their research funding and facilitation. We also thank the Fisheries Laboratory, Faculty of Natural Resources and Agro-Industry, Kasetsart University Chalermphrakiat Sakon-nakhon Province Campus for providing research facilities.

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