



Study of Surface Water Quality Using Biological Indicators Inside the Ruean Thai Pond Area, Nakhon Si Thammarat Rajabhat University

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Abstract: Biological monitoring using macroinvertebrate bioindicators provides an ecologically integrative approach to water quality assessment, capturing cumulative pollution effects that physicochemical measurements alone cannot reflect. This study assessed the surface water quality of the Ruean Thai Pond, a natural spring-fed water body within Nakhon Si Thammarat Rajabhat University, using aquatic macroinvertebrate assemblages. Five sampling stations were established along the pond. Sampling was conducted four times over two months (September–October 2021), totaling 20 station-sampling events. Aquatic insect larvae and associated bioindicator organisms were collected using brick substrates and colander nets, then identified to family level and classified into water quality categories according to the Stream Detective Manual (Green World Foundation, 2018). A total of 13 bioindicator types (morphotypes) representing 5 orders and 9 families were recorded. Ephemeroptera was the most diverse order with 3 families (*Leptophlebiidae*, *Potamanthidae*, *Baetidae*), followed by *Gastropoda* and *Trichoptera* (2 families each), and *Caridea*, *Odonata*, and *Hemiptera* (1 family each). "Very clean water" bioindicators — branched-gill and feathered-gill mayfly larvae (*Leptophlebiidae*, *Potamanthidae*) and cased and uncased caddisfly larvae (*Odontoceridae*, *Hydropsychidae*) — dominated Stations 2–5, accounting for 54–78% of total bioindicator counts. Station 1 (pond entrance station) was the only station classified as "fair-clean," where fair-category organisms ($n = 30$) outnumbered very-clean-category organisms ($n = 0$). Four of five stations (80%) were consistently classified as "very clean water" across all sampling rounds, yielding an overall classification of "very clean" for the Ruean Thai Pond. These findings provide a preliminary wet-season biological assessment for university water resource management and for downstream community water-use planning.

Keywords: Water quality; macroinvertebrates; bioindicators; ephemeroptera; Thailand

1. Introduction

Water is an essential resource for all living organisms. Despite covering approximately 70% of the Earth's surface, only about 1% of the total global water volume is conveniently accessible for human consumption or agriculture [1]. Surface waters, including rivers, ponds, and lakes, account for only 0.6% of global freshwater and are particularly vulnerable to pollution from agricultural, industrial, and domestic sources [2]. Thailand has faced persistent water-resource challenges over recent decades, including severe drought, degraded water sources, and heavy flooding, exacerbated by a growing population, climate change, and inadequate water-management strategies [3–5]. Maintaining water quality in natural surface water bodies

located within educational institutions is particularly important, as these systems serve local communities and support aquatic biodiversity.

Conventional water quality assessment relies on physicochemical and bacteriological parameters [6]. However, biological monitoring using macroinvertebrates, especially aquatic insect larvae, provides an integrative measure of ecological health by reflecting cumulative exposure to environmental stressors over time [6]. Benthic macroinvertebrates are widely used as bioindicators because different taxa exhibit distinct tolerances to dissolved oxygen and organic pollution [7, 8]. Clean water sources support sensitive groups such as mayfly larvae (Ephemeroptera) and stonefly larvae (Plecoptera), whereas polluted waters are dominated by tubificid worms and red midge larvae [9]. Nakhon Si Thammarat Rajabhat University contains a natural surface water body known as the "Kha Mahachai Stream," which flows through the campus and into surrounding communities. The Ruean Thai Pond within this stream network serves as an important habitat for diverse aquatic organisms. Despite its ecological significance, systematic biological water quality monitoring has not previously been conducted at this site [10]. This study aimed to (1) survey the diversity of aquatic insect larvae and other bioindicator organisms in the surface water of the Ruean Thai Pond, and (2) assess water quality at five sampling stations using the Stream Detective Manual (Green World Foundation, 2018) as the classification standard.

2. Materials and Methods

2.1 Study Area

The study was conducted at the Ruean Thai Pond located within Nakhon Si Thammarat Rajabhat University (approximately 8°25'N, 99°58'E), Nakhon Si Thammarat Province, southern Thailand. The pond is a section of the Kha Mahachai Stream, a natural, spring-fed waterway that flows through the campus. Five sampling stations were established across the pond area (Fig. 1).

Station 1: Ruean Thai entrance area (pond entrance station — spatial starting point of transect)

Station 2: Bridge behind Building 28 (Cultural Center)

Station 3: Ruean Thai, adjacent to the Demonstration School

Station 4: Area behind Building 53

Station 5: Bridge behind Building 8 (Arts and Culture College)

2.2 Sampling Procedure and Schedule

Sampling was conducted four times over two months (September–October 2021), with collections on 1 September, 15 September, 1 October, and 15 October 2021, between 09:00 and 12:00 h at each station. Aquatic insect larvae and associated bioindicator organisms were collected using a standard colander-net by sweeping bank margins, leaf litter, and submerged substrates. Brick substrates (approximately 20 × 10 × 5 cm) were placed at each station for organism attachment and retrieved during each collection event [11]. Collected organisms were transferred to a white tray for sorting. Identification was performed under a hand lens against pictorial identification cards of the Stream Detective Kit (Green World Foundation, 2018), and organisms were assigned to bioindicator categories: very clean water, clean water, fair water, dirty water, or non-indicator [12].

2.3 Equipment

Standard equipment used in this study included the Stream Detective Kit (Green World Foundation, 2018), basins, colander nets, spoons, and cups for sorting, hand lenses (×10), brick substrates, nylon rope, field notebooks, and digital cameras.

2.4 Data Analysis

Water quality at each station and sampling event was determined by the dominant bioindicator group recorded, following the scoring criteria of the Stream Detective Manual. Overall water quality per station was assessed across all four sampling rounds and summarized in comparative tables and bar graphs.

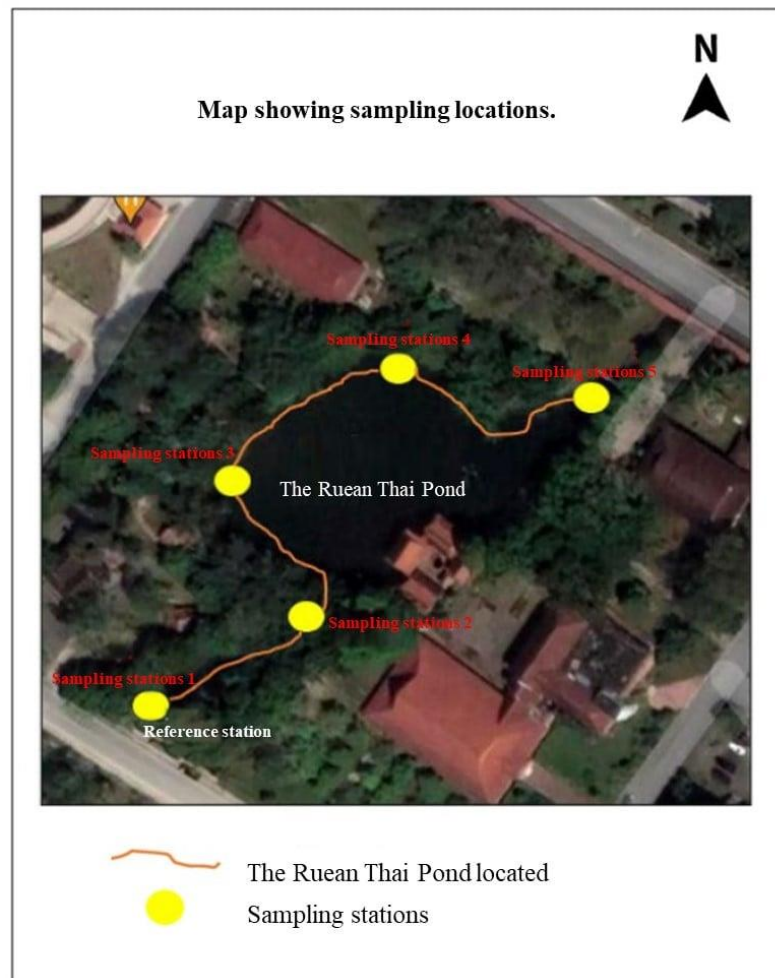


Figure 1. Map of the Ruean Thai Pond within Nakhon Si Thammarat Rajabhat University showing the five surface water sampling stations: Station 1 (pond entrance), Station 2 (bridge behind Building 28, Cultural Centre), Station 3 (Ruean Thai area adjacent to the Demonstration School), Station 4 (behind Building 53), and Station 5 (bridge behind Building 8, Arts and Culture College). Sampling was conducted four times over two months (September–October 2021).

3. Results and Discussion

3.1 Diversity of Bioindicator Organisms

A total of 6 orders and 9 families of aquatic insects and associated organisms were recorded across all five stations and four sampling events (Table 1). The order *Ephemeroptera* (mayflies) was the most species-rich, represented by 3 families (*Leptophlebiidae*, *Potamanthidae*, and *Baetidae*). Gastropoda and Trichoptera each contributed 2 families, while Caridea and Hemiptera each contributed 1 family (Table 2). The diversity of bioindicator taxa recorded in this study is consistent with findings from comparable university pond surveys in Thailand. Phrommi et al. [13] reported similar Ephemeroptera-dominated communities in freshwater ponds at Kasetsart University, while Rungnapa and Thattaporn [14] documented EPT assemblages (Ephemeroptera, Plecoptera, Trichoptera) as characteristic of good-quality streams in northern Thailand.

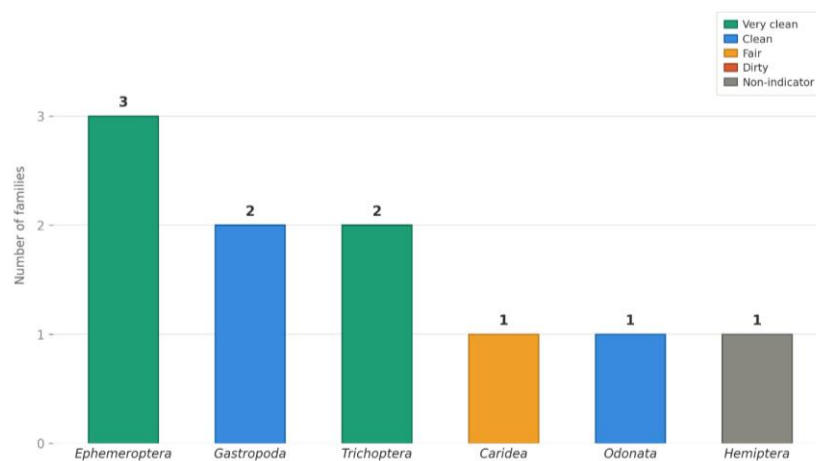
Table 1. Summary of bioindicator taxa recorded in the Ruean Thai Pond (September–October 2021).

Bioindicator Organism	Family	Order	Water Quality Category
Branched-gill mayfly larva	<i>Leptophlebiidae</i>	<i>Ephemeroptera</i>	Very clean
Feathered-gill mayfly larva	<i>Potamanthidae</i>	<i>Ephemeroptera</i>	Very clean
Cased caddisfly larva	<i>Odontoceridae</i>	<i>Trichoptera</i>	Very clean
Uncased caddisfly larva	<i>Hydropsychidae</i>	<i>Trichoptera</i>	Very clean
Tower snail	<i>Thiaridae</i>	<i>Gastropoda</i>	Clean
Short dragonfly larva	—	<i>Odonata</i>	Clean
Waterfall shrimp	<i>Palaemonidae</i>	<i>Caridea</i>	Clean
Freshwater shrimp (Goby shrimp)	<i>Palaemonidae</i>	<i>Caridea</i>	Fair
Single-valve snail	<i>Viviparidae</i>	<i>Gastropoda</i>	Fair
Swimming mayfly larva	<i>Baetidae</i>	<i>Ephemeroptera</i>	Fair
Red midge larva	<i>Chironomidae</i>	—	Dirty
Sewage worm	<i>Tubificidae</i>	—	Dirty
Water strider	<i>Gerridae</i>	<i>Hemiptera</i>	Non-indicator

A total of 5 orders (plus infraorder Caridea within Decapoda) and 9 families of aquatic insects and associated organisms were recorded across all five sampling stations (Fig. 2). The order Ephemeroptera (mayflies) was the most taxonomically diverse, represented by 3 families: *Leptophlebiidae* (branched-gill mayfly larvae), *Potamanthidae* (feathered-gill mayfly larvae), and *Baetidae* (swimming mayfly larvae). Gastropoda and Trichoptera each contributed 2 families, while Caridea, Odonata, and Hemiptera each contributed 1 family (Figure 2; Table 1). In terms of water quality indication, organisms classified as "very clean water" bioindicators dominated the recorded assemblage, including larvae of *Leptophlebiidae*, *Potamanthidae*, *Hydropsychidae*, and *Odontoceridae* — all taxa sensitive to dissolved oxygen depletion. Organisms tolerant of moderate oxygen reduction ("fair water" category), such as *Palaemonidae* shrimp and *Viviparidae* snails, were also present at several stations, particularly Station 1. Two taxa associated with "dirty water" conditions (*Chironomidae* red midge larvae and *Tubificidae* sewage worms) were recorded at low abundance at Stations 3 and 4, while *Gerridae* (water striders, order Hemiptera) were classified as non-indicators due to their ability to inhabit any water condition.

3.2 Water Quality Assessment by Station

The total counts of bioindicator organisms recorded at each station across all four sampling rounds are summarized in Figure 3. Marked differences in assemblage composition were observed between Station 1 and Stations 2–5. At Station 1 (pond entrance), organisms indicating "fair" water quality were most abundant, with *Palaemonidae* shrimp and *Viviparidae* snails collectively accounting for 30 individuals, followed by "clean" water indicators (*Thiaridae* snails, $n = 21$). No "very clean" bioindicators were recorded at this station (Fig. 3). Overall water quality classification: fair–clean. At Station 2, "very clean" bioindicators dominated the assemblage ($n = 26$), comprising primarily caddisfly larvae (*Hydropsychidae*, *Odontoceridae*) and mayfly larvae (*Leptophlebiidae*, *Potamanthidae*), alongside a subset of "fair" indicators ($n = 15$). Overall classification: very clean. At Station 3, "very clean" bioindicators were overwhelmingly dominant ($n = 32$), represented mainly by branched-gill mayfly larvae (*Leptophlebiidae*) and feathered-gill mayfly larvae (*Potamanthidae*). A small number of "dirty" water indicators ($n = 2$) were recorded but did not alter the overall classification (Figure 3).



Order	Families (n)	Families recorded	Water quality category
Ephemeroptera	3	Leptophlebiidae, Potamanthidae, Baetidae	Very clean / Fair
Gastropoda	2	Thiaridae, Viviparidae	Clean / Fair
Trichoptera	2	Hydropsychidae, Odontoceridae	Very clean
Caridea	1	Palaemonidae	Clean / Fair
Odonata	1	—	Clean
Hemiptera	1	Gerridae	Non-indicator

Figure 2. Number of families recorded per aquatic insect order in the Ruean Thai Pond surface water, classified by water quality indication category according to the Stream Detective Manual (Green World Foundation, 2018). A total of 9 families across 6 orders were recorded. Ephemeroptera was the most taxonomically diverse order with 3 families, followed by Gastropoda and Trichoptera (2 families each).

Overall classification: very clean. At Station 4, "very clean" bioindicators remained dominant across all four sampling rounds ($n = 22$), with "fair" indicators present at lower abundance ($n = 8$) and a minor occurrence of "dirty" water organisms ($n = 2$). Overall classification: very clean. At Station 5, the highest proportion of "clean" water indicators among Stations 2–5 was recorded ($n = 8$), while "very clean" bioindicators continued to dominate ($n = 28$). No "dirty" organisms were detected (Fig. 3). Overall classification: very clean. Across all five stations, Stations 2–5 consistently yielded a "very clean" classification, whereas Station 1 was classified as "fair–clean" (Fig. 3). The lower water quality at Station 1 likely reflects the accumulation of allochthonous organic material at the pond entrance. This pattern may reflect the accumulation of allochthonous organic material (leaf litter, surface runoff) at the pond entrance. However, as the Ruean Thai Pond is a lentic (not lotic) system, applying a riverine longitudinal gradient model is imprecise; a dedicated physicochemical investigation at Station 1 is recommended to identify specific stressors [12, 15].

3.3 Overall Water Quality

Considering all five stations collectively, the Ruean Thai Pond is classified as "very clean water," as organisms in the very clean category—particularly branched-gill mayfly larvae (Leptophlebiidae), feathered-gill mayfly larvae (Potamanthidae), cased caddisfly larvae (Odontoceridae), and uncased caddisfly larvae (Hydropsychidae)—dominated the bioindicator community across most stations and sampling events. The continuous flow of water through the system maintains adequate dissolved oxygen concentrations, supporting these oxygen-sensitive groups. The co-occurrence of "dirty water" bioindicators (red midge larvae, sewage worms) and "very clean" bioindicators at certain stations is consistent with the behavioral adaptability

of some taxa and local substrate heterogeneity, rather than indicating a deterioration in overall water quality. Similar co-occurrence patterns have been noted by Issara et al. [15] in streams with heterogeneous habitat patches.

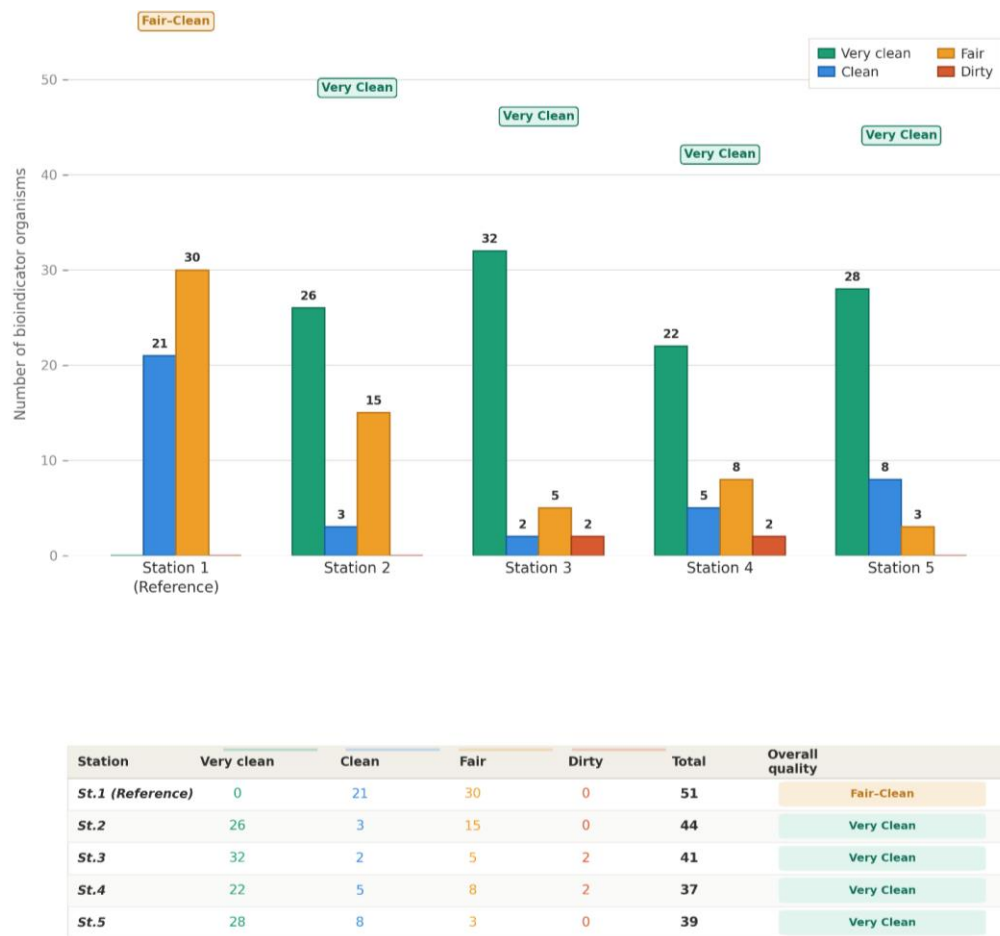


Figure 3. Total counts of bioindicator organisms by water quality category recorded at five sampling stations in the Ruean Thai Pond surface water (September–October 2021, 4 sampling rounds combined). Badges above each group indicate the overall water quality classification for each station, based on the dominant bioindicator category, as defined in the Stream Detective Manual (Green World Foundation, 2018).

Table 2. Comparative summary of bioindicator counts across all five stations (total counts, all four sampling events).

Station	Very Clean	Clean	Fair	Dirty	Overall Quality
1 (Reference)	0	21	30	0	Fair–Clean
2	26	3	15	0	Very Clean
3	32	2	5	2	Very Clean
4	22	5	8	2	Very Clean
5	28	8	3	0	Very Clean

4. Conclusions

This survey of the Ruean Thai Pond at Nakhon Si Thammarat Rajabhat University recorded 5 orders (plus infraorder Caridea within Decapoda) and 9 families of aquatic insects and associated organisms. Using biological indicators in accordance with the Stream Detective Manual criteria, the pond's overall water quality was assessed as "very clean," primarily supported by the dominance of Ephemeroptera and Trichoptera larvae, which require high dissolved oxygen. These findings provide a preliminary wet-season biological assessment

for water resource management within the university [17, 18] and can serve as a reference for communities downstream of the campus. Continuous biological monitoring across multiple seasons is recommended to track temporal trends in water quality and to establish a year-round ecological baseline. Future studies should incorporate physicochemical measurements (dissolved oxygen, temperature) and standardized quantitative sampling to strengthen the bioassessment framework for this important campus water body [16, 17, 18].

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