Water Quality and Freshwater Macroinvertebrate Diversity at Kaeng Krachan Dam, Phetchaburi Province

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Abstract

This study investigated the diversity of freshwater macroinvertebrates in Kaeng Krachan Dam as a means of assessing the dam's water quality. To investigate the influence of water quality on aquatic insect diversity and abundance, we collected freshwater macroinvertebrates from five stations in Kaeng Krachan Dam, Phetchaburi Province. These stations represented contrasting environments: three stations (S1) in resort areas with continuous water flow and minimal waste accumulation, and three stations (S2, S3, S4) with high human activity. As we move downstream, the concentration of waste gradually decreases. This is because points S4 and S5 are separated by a dilution zone, where pollutants naturally disperse and the water becomes cleaner. Consequently, S5 exhibits lower levels of waste compared to S4.

Keywords: *Macroinvertebrates, Biodiversity, Water Quality*

1. Introduction

Many freshwater macroinvertebrates are sensitive to pollution but some might be able to live in extreme polluted water (Merritt & Cummins, 1996; Hepp et al., 2013; Backhaus et al., 2019). Anthropogenic activities are major causes of pollution loads and alteration of water physicochemical properties. Main anthropogenic activities are domestic sewage and run-off from agricultural lands (Chedadi et al., 2022). Water physicochemical properties that tend to be affected include water temperature, pH, and salinity. Changes in these water characteristics significantly impact where macroinvertebrates are found, as some are extremely vulnerable to pollution, while others exhibit varying degrees of tolerance or complete resistance to environmental disruptions.

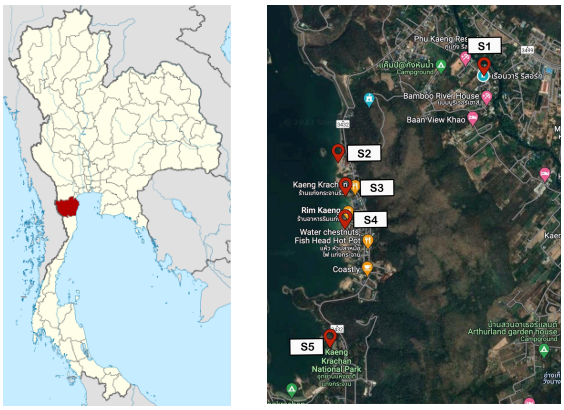
Integrating biological parameters to physiochemical assessments give a complete method to assess water pollution affecting freshwater ecosystems (Resh et al., 1996; Oliveira & Cortes, 2006; Suhaila et al., 2014; Chancay et al., 2021). Freshwater benthic macroinvertebrates are crucial organisms utilized in bioassessment studies, aiding in the assessment of present environmental pollutants and their extent. Some benthic freshwater macroinvertebrates respond to specific changes in water conditions becoming bioindicators to detect water health conditions. The presence and absence of benthic freshwater macroinvertebrates indicate the degree of water pollution. Physicochemical assessment can be used to identify some causes of water pollution (Gupta & Paliwal 2010).

The aim of this study was to investigate anthropogenic activity (releases from domestic sewage) on water quality and freshwater macroinvertebrate diversity at Kaeng Krachan Dam. We hypothesized that water quality and freshwater macroinvertebrate diversity indices decreased as the anthropogenic activity increased. In this study, we collected the benthic freshwater macroinvertebrates at five study sites at Kaeng Krachan Dam, identified them up to the species and genus level, assessed the water quality status, and determined how water quality status influenced freshwater macroinvertebrate diversity and richness.

2. Materials and Methods

2.1 Study Site

This study was conducted at Kaeng Krachan Dam, Phetchaburi Province, Central Thailand (Figure 1a, 1b). We collected water parameters at five stations, with Station 1 (S1: 12.90600°N, 99.64256°E) being a river area draining to the Kaeng Krachan Dam (Figure 1b, S1). Three stations had high anthropogenic activity (restaurants and local villages) (S2: 12.89915°N, 99.63283°E; S3: 12.89839°N, 99.63284°E; S4: 12.89601°N, 99.63254°E). Local restaurants did not discharge wastewater into the Kaeng Krachan Dam (Figure 1b, S2, S3). However, local villagers discharged wastewater into the Kaeng Krachan Dam (Figure 1b, S4). The fifth station was located at Kaeng Krachan National Park, where water was less affected by human activities (S5: 12.88609°N, 99.63104°E) (Figure 1b, S5).



(a) **(b)**

Figure 1. (a) Map of Thailand and **(b)** five water sampled stations at Phetchaburi Province, Thailand

2.2 Freshwater Macroinvertebrate Sampling

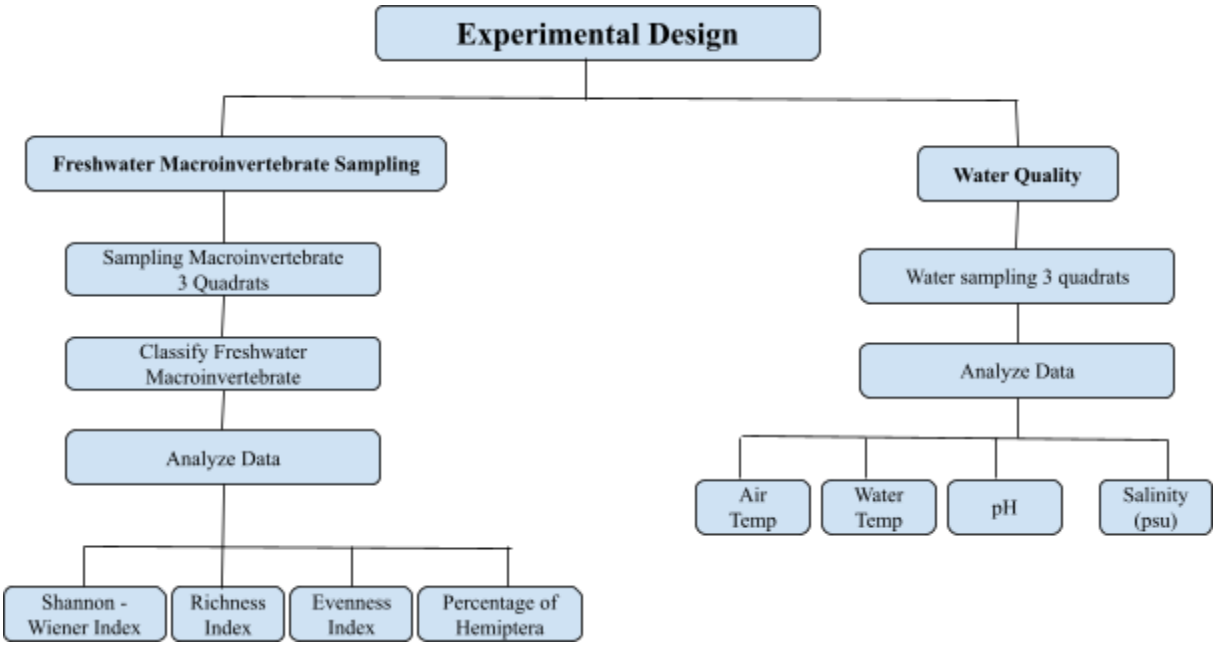


Figure 2. Experimental design of the study

Macroinvertebrates inhabiting freshwater environments were sampled according to the GLOBE freshwater macroinvertebrates protocol. This involved employing a standardized D-hand net with a 50×50 cm2 frame, 250 µm mesh sieve, and a 50-cm long handle. The D-hand net was consistently used throughout the sampling process. We collected freshwater macroinvertebrates from five designated stations (S1-S5). Within each station, we sampled a 15-meter stretch. Three replicate samples were collected per station at each site, capturing all microhabitats across representative sections. Spread across white trays, the freshwater macroinvertebrates awaited meticulous sorting and screening. Skilled hands then carefully picked out each specimen. Delicate fingers plucked the tiny freshwater creatures from the metal tray, their translucent bodies glistening in the sunlight. The contents of each sample collected with the net were carefully placed into appropriately labeled plastic containers and transported to the laboratory for analysis. In the lab, freshwater macroinvertebrates were sorted on a Petri dish and identified to the family level using taxonomic keys from various authors (Dudgeon 1999; Wiggins 1996; Yule & Sen 2004). Specifically, larger benthic freshwater macroinvertebrates were focused on during this process.

2.3 Water Quality Parameters

GLOBE hydrosphere protocols were employed to measure a range of water parameters at five distinct stations: S1-S5. A representative 15-meter stretch was chosen within each site to encompass the range of microhabitats present for sample collection.Three replicate samples were collected per station, capturing diverse microhabitats across representative sections. Just prior to

collecting freshwater macroinvertebrates, we gathered water samples from each sampling site. Three replicates of selected physicochemical water quality parameters, encompassing pH, water temperature, and salinity, were directly measured at the sampling site.

2.4 GLOBE Observer App

The GLOBE Observer: Cloud App was employed to gather data on cloud types and the percentage of cloud cover at the five study sites. This application, part of the GLOBE Program, facilitates environmental observations that supplement NASA satellite data, supporting scientists in their study of Earth and the global environment (Figure 3).

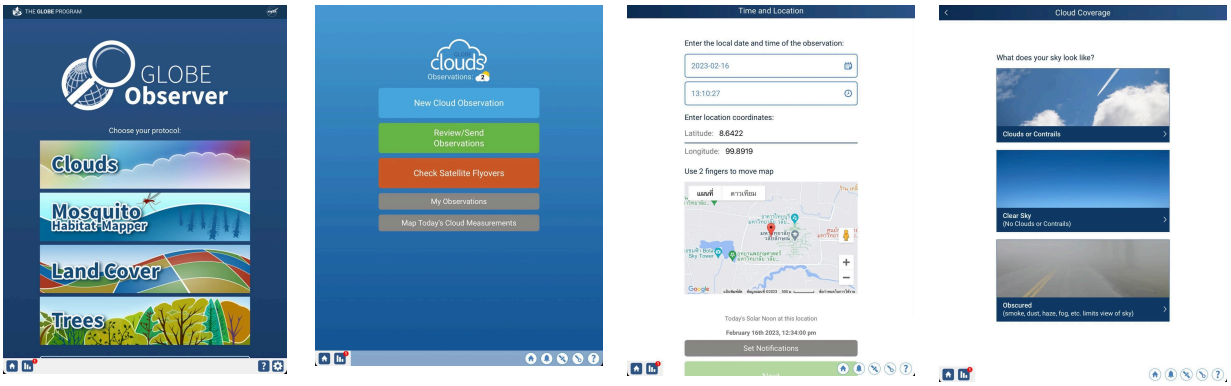


Figure 3. GLOBE Observer: Clouds App

2.5 Biological Indices

To evaluate water quality at the sampling site, the identified freshwater macroinvertebrates were analyzed using established biological index protocols.

1. **Shannon-Wiener Index (H′)**

Shannon-Wiener Index (H′) is a way to measure the diversity of species in a community. Abundance and equality will be explained, which will be used to identify the characteristics of species diversity The Shannon-Wiener Index (H′) value is directly different to water quality.

2. **Richness Index**

Margalef's Index, a measure of species richness, normalizes for sample size by dividing the number of species in a sample by the natural logarithm of the total number of organisms collected (Margalef, 1958).

Margalef's Index = (S – 1) / In N

S = total number of species

N = total number of individuals in the sample

In = natural logarithm

3. Evenness Index

For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1966).

$$e = H / \ln S$$

H = Shannon-Wiener diversity index
S = total number of species in the sample

4. Percentage of Hemiptera

The total number of flies (Order Hemiptera) was divided by the total number of organisms in the sample and multiplied by 100. If the value was higher than 40%, 20% to 40%, and less than 20%, the conditions are considered to be poor, moderate, and good.

3. Data Analysis

The taxonomic composition of freshwater macroinvertebrates and the physicochemical parameters underwent comparison using one-way analysis of variance (ANOVA). Bonferroni's post hoc tests were employed for multiple comparisons of the means of physicochemical parameters to assess similarities among sampling points. Simple linear regression was utilized to establish the relationship between water pH and temperature with the Shannon-Wiener Index, while diversity was assessed using this index. Taxa richness, represented by the number of aquatic macroinvertebrate families found in the samples, was determined through a straightforward count.

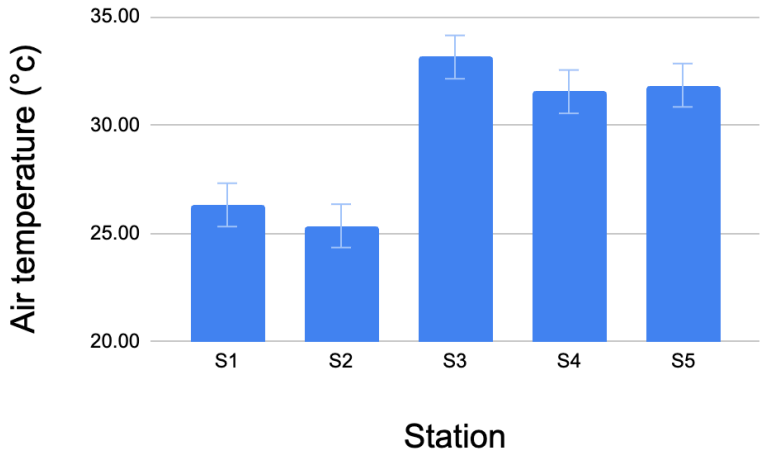
4. Results and Discussion

4.1 Physical and Chemical Properties of the Sample

The air temperature had an average of 29.64±3.28°C with a range of 25.35-33.14°C. Air temperature of all five stations differed from each other (One-way ANOVA) $F_{4,10}$ = 37,566.355, $P < 0.001$ (Figure 4a). The water temperature had an average of 27.19±1.07°C with a range of 25.80-28.43°C. Water temperature of all five stations differed from each other (One-way ANOVA) $F_{4,10}$ = 93.871, $P < 0.001$ (Figure 4b). The pH had an average of 7.33±0.63 with a range of 6.78-7.95. pH of all five stations differed from each other (One-way ANOVA) $F_{4,10}$ = 3.567, $P < 0.001$ (Figure 4c).

For the results of physical and chemical water quality analysis in all five stations around Kaeng Krachan Dam, Phetchaburi Province (Table 1), it was found that the average air temperature was in the range of 25.30-33.10°C and the water temperature was in the range of 25.80-28.70°C. Generally, living things can be able to live in tropical countries. Thailand has water temperatures that vary between the range of 23.00- 32.00°C. The average values of air and water temperatures in each study area are different. This could be due to the fact that the time of day we sampled the water differed among sites and some sites might be more shady than others. Station 1 (S1) had high canopy covers and over hanging trees, which resulted in lower air and water temperature than other sites. The average pH was found to be in the range of 6.02-8.03, which is commonly found in natural water sources. The pH value is suitable for life of aquatic macroinvertebrates. The average value is in the range 6.50-9.00 and the average salinity is 0.1 PSU, which is a normal value found in freshwater.

(a)


35.00
30.00
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Air temperature (°c)
S1
S2
S3
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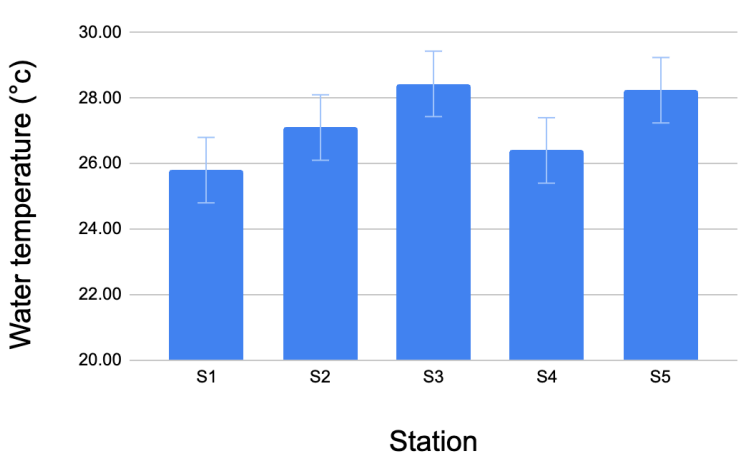
S5
Station

(b)


30.00
28.00
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22.00
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Water temperature (°c)
S1
S2
S3
S4
S5
Station

(c)

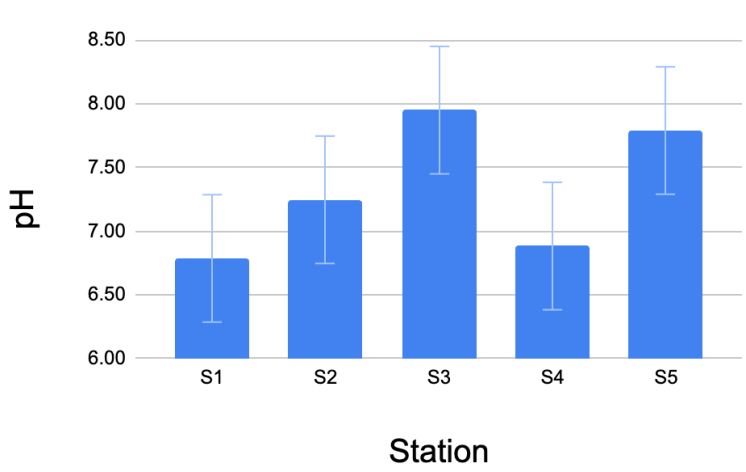
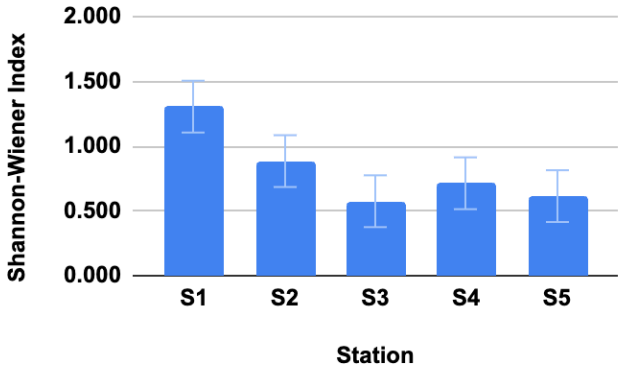

8.50
8.00
7.50
7.00
6.50
6.00
pH
S1
S2
S3
S4
S5
Station

Figure 4. Physico-chemical water quality parameter (mean ± SD) from five study sites of Kaeng Krachan Dam, Phetchaburi Province: (a) Air temperature, (b) Water temperature and (c) pH

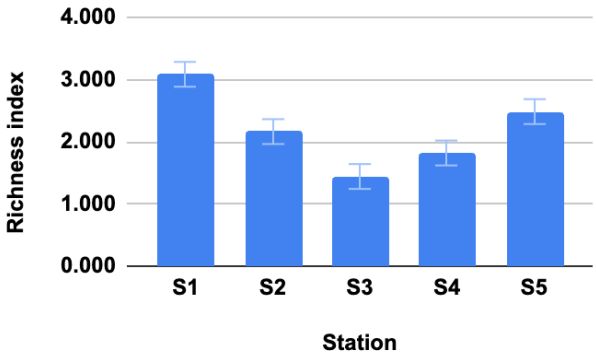
4.2 Distribution and Diversity of Aquatic Insects within the Kaeng Krachan Dam Area

The Shannon-Wiener Indices had an average of 0.77±0.24 with a range of 0.57-1.17. The Shannon-Wiener Indices of all five stations differed from each other (One-way ANOVA: $F_{4,10}$ = 8.002, P < 0.001, Figure 5a). The Margalef's Richness Index had an average of 2.10 ± 0.59 with a range of 1.44-3.08. The Margalef's Richness Index of all five stations differed from each other (One-way ANOVA: $F_{4,10}$ = 30.750, P < 0.001, Figure 5b). The Pielou's Evenness Index had an average of 0.63±0.14 with a range of 0.53-0.82. The Pielou's Evenness Index of all five stations differed from each other (One-way ANOVA: $F_{4,10}$ = 3.307, P < 0.001, Figure 5c).

(a)



(b)



(c)

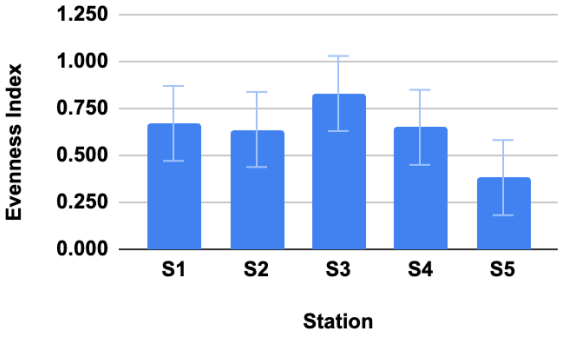


Figure 5. Physico-chemical diversity parameter (mean±SD) from five study sites of Kaeng Krachan Dam, Phetchaburi Province: (a) Shannon-Wiener Index, (b) Margalef's Richness Index, and (c) Pielou's Evenness Index

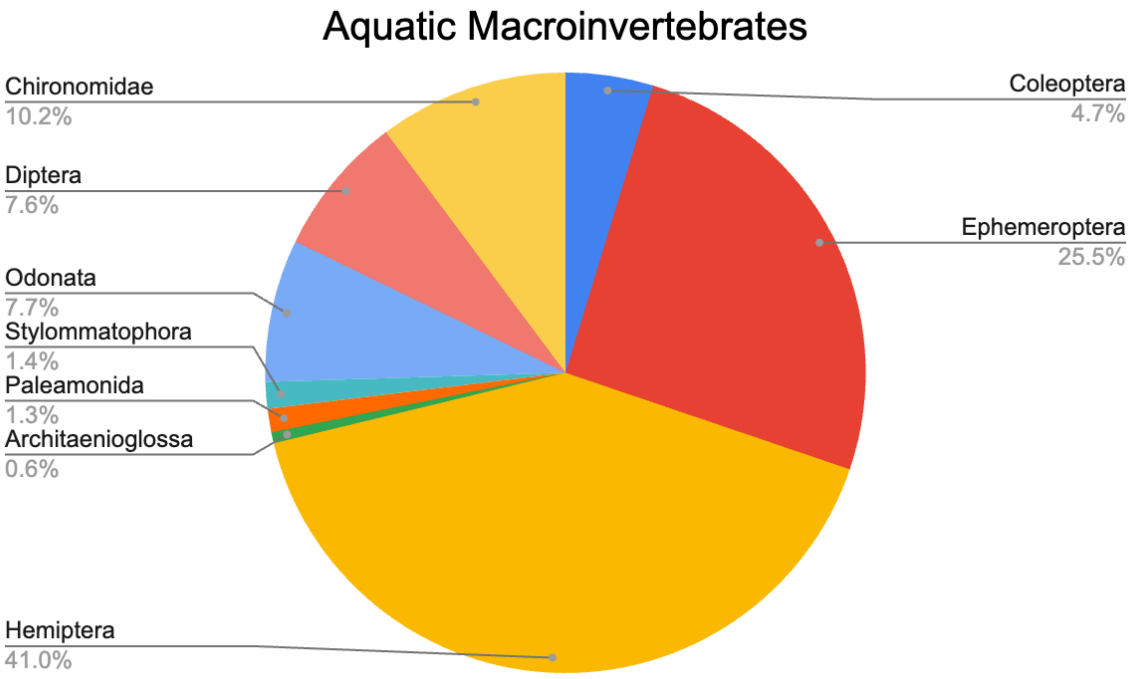


Figure 6. Proportion of distribution of aquatic insects in Kaeng Krachan Dam, Kaeng Krachan District, Phetchaburi Province

The distribution and diversity of aquatic insects in all five stations within the Kaeng Krachan Dam area are shown in Figure 6. There were a total of 902 aquatic insect samples found in nine orders: Hemiptera (41%), Ephemeroptera (25.5%), Chironomidae (10.2%), Odonata (7.7%), Diptera (7.6%), Coleoptera (4.7%), Stylommatophora (1.4%), Paleamonida (1.3%), and Architaenioglossa (0.6%).

Order Hemiptera was found in the highest number with a total of 486 individuals, accounting for 41.01%. Within Hemiptera, *Anisops* sp. (water boatmen) had the highest numbers with a total of 283 individuals, followed by Gerridae with a total number of 203 individuals. The second highest number was Ephemeroptera with a total number of 302 individuals (25.49%), followed by Chironomidae with a total number of 121 individuals (10.21%), Odonata with a total number of 91 individuals (7.68%), Diptera with a total number of 90 individuals (7.59%), Coleoptera with a total number of 56 individuals (4.73%), Stylommatophora with a total number of 17 individuals (1.43%), Palaemonidae with a total number of 15 individuals (1.27%), and Architaenioglossa with a total number of 7 individuals (0.59 %) (Figure 6).

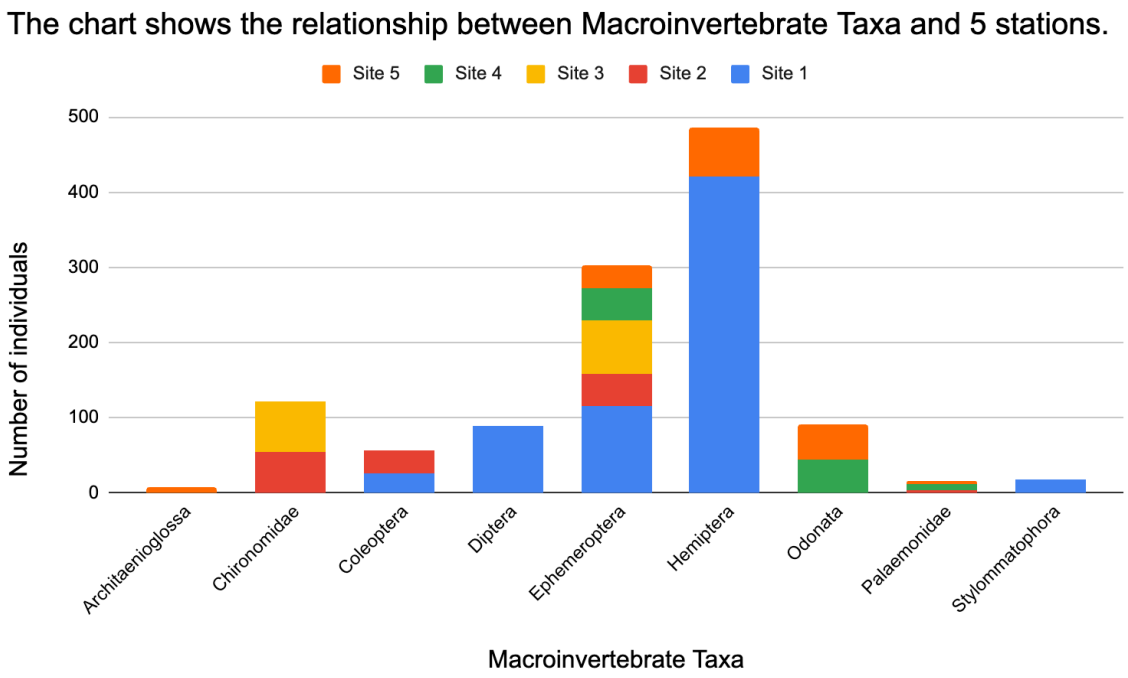


Figure 7. Order of diversity and distribution of aquatic insects in the Kaeng Krachan Dam area

From Figure 7, Study Site 1 had the highest diversity of aquatic insects. We found five orders of aquatic insects: Coleoptera, Dipterra, Ephemeroptera, Hemiptera, and Stylommatophora. The Study Site 2 had the second highest diversity of aquatic insects. We found five orders of aquatic insects: Architaenioglossa, Ephemeroptera, Hemiptera, Odonata, and Paleamonida. Odonata was found at Study Site 4 and 5, representing the intermediate water quality level.

The third stations found Chironomidae and Ephemeroptera. The fourth stations found aquatic insects in the order Ephemeroptera. There was a large spread, the best among all educational stations. Most invasive aquatic insects are organized into groups that can indicate the level of good water quality. Medium water and wastewater included especially the group Ephemeroptera, an aquatic insect with many larvae that are less resistant to environmental changes. They cannot live in areas with polluted water. Therefore, this group of aquatic insects is important in measuring water quality when considering Study Site 1 with the highest prevalence of aquatic insects in the order of Ephemeroptera (116). Because Mayflies are resistant to changes in environmental conditions, they are found in good to fair quality water. Therefore, this group of aquatic insects is the main type used in evaluating the quality of water sources. Diversity of habitat is affected by the characteristics of aquatic insects and the characteristics of aquatic plants. In the case of Kaeng Krachan Dam, it is an area that is being used by human activities. But there is wastewater treatment all the time. As a result, the Kaeng Krachan Dam area has little water contamination.

4.3 Water-Quality Factors in Study Areas

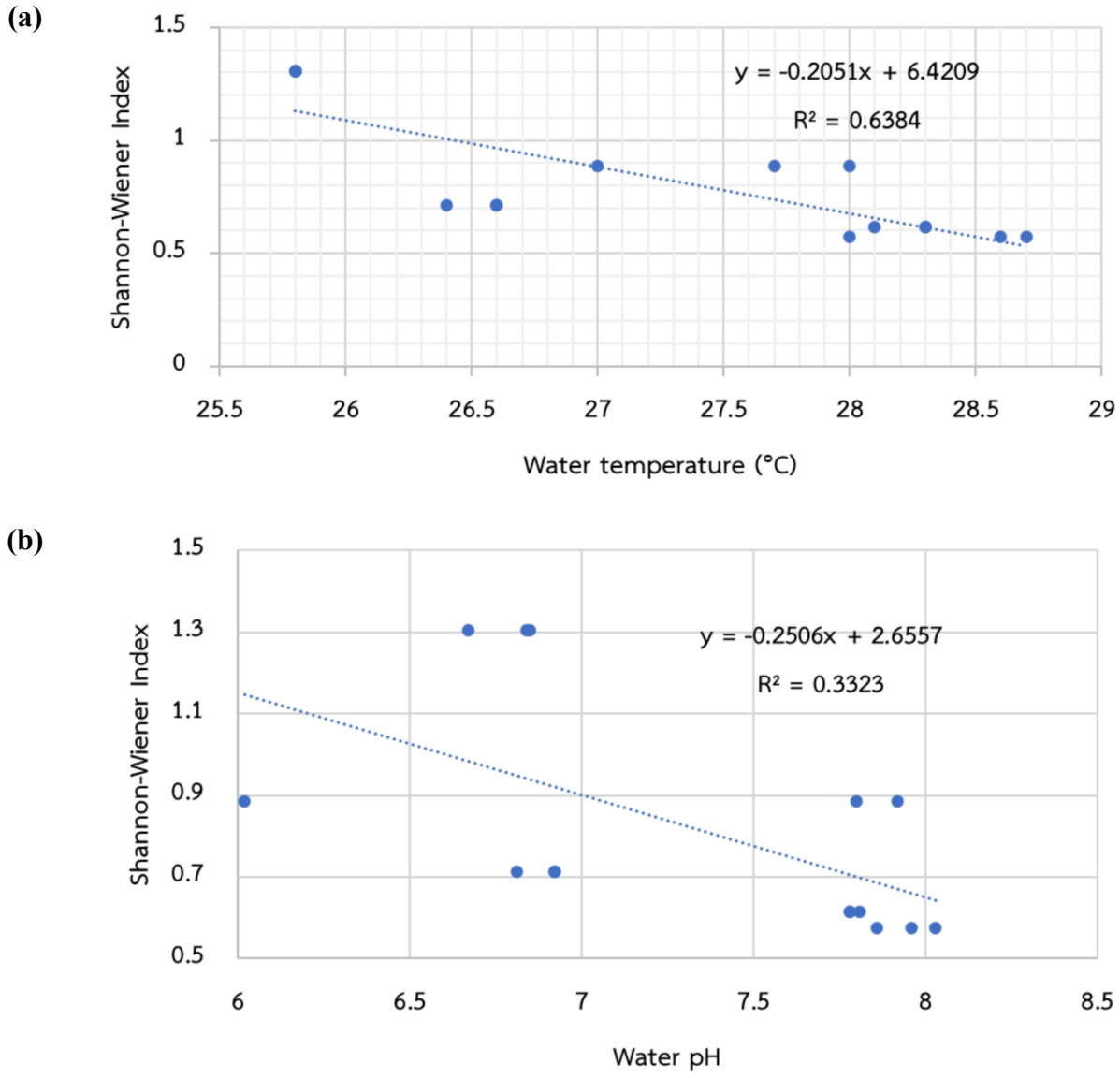


Figure 8. Water-quality factors in study areas with minimum-maximum average (a) water temperature (°C) and (b) water pH

Water quality data were analyzed in the five study stations. Overall, it was found that most of the average water quality data were within the appropriate criteria for aquatic animals. For the relationship between invertebrates and environmental factors, especially water quality, the study found that the density of Hemiptera and Ephemeroptera were significantly higher and had a negative but not statistically significant relationship ($p > 0.05$) with water temperature and pH.

5. Conclusion

This report details the findings of a survey conducted on the macroinvertebrate community within the Kaeng Krachan Dam ecosystem, Phetchaburi Province. Ten species, categorized into seven taxonomic groups (Hemiptera, Ephemeroptera, Chironomidae, Odonata, Diptera, Coleoptera, and Stylommatophora) were recorded, providing valuable insights into the ecosystem's health and biodiversity. Hemiptera was the dominant species number (41% of all specimens), and the highest in quantity Ephemeroptera was the most dominant species (25.5%). The Shannon-Wiener and Margalef Indices span a range of 0.88 to 3.08, with Shannon-Wiener falling between 0.88 and 1.33 and Margalef between 1.44 and 3.08. Puttapreecha et al. (2016) had found a diverse assemblage of macroinvertebrates in Talet Bay, Nakhon Si Thammarat Province, comprising 6 phyla and 248 species, with abundances ranging from 125 to 4,650 individuals per square meter.

Physical and chemical water quality factors within the Kaeng Krachan Dam area were studied at five stations. The average air temperature was between 25.30-33.10°C. The average water temperature, pH, and salinity ranged between 25.80-28.70°C, 6.02-8.03, and 0.1 psu, respectively. Kaeng Krachan Dam is a major tourist attraction. In this study, we found a total of 9 orders of aquatic insects, 11 families, 902 individuals, with the S4 area having the most water pollution. This is because we found river skimmer and Lanchester freshwater prawn, which are invertebrates that indicate dirty water quality, followed by S5 where river skimmer and Lanchester freshwater prawn were also found in smaller quantities because S5 is downstream where water has been diluted. Dirty water comes from S4, while S3 is the restaurant area. There will be fair water quality because the restaurant will have wastewater treated before releasing it into the S2 dam, which is a government agency area. There is no use of water from the dam, and so the water quality is average, and S1 is the source of water in the resort area. There is no wastewater treatment. But there is water flowing throughout, making the water quality good.

At Kaeng Krachan Dam, Phetchaburi Province, the period is between the rainy season and winter. This causes the discovery of nimbostratus clouds, which indicate the occurrence of light rain. And because there is little rain, the water temperature will be in the range between 28.62-29.61°C, making it possible to encounter nine aquatic macroinvertebrates.

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I would like to claim IVSS badges

1. I make an impact

   The report meticulously traces a local issue to the birth of the research questions, illuminating its critical role in shaping the study. Bridge the gap between research and reality! Show how your work translated into positive outcomes for the community, either through impactful recommendations or direct engagement. This study will give you an idea of how invertebrate species can be linked to the pH content of water. This is because some invertebrates cannot live in water with a high pH (dirty water).
2. I am a STEM professional

   The report showcases the profound impact of STEM expertise. The research benefitted from refined methods, enhanced accuracy, and more nuanced interpretations, all thanks to the collaboration. This study uses software to measure diversity. This allowed us to do research with many more samples.
3. I am a data scientist

   The cornerstone of the report is an in-depth analysis of student-generated data, alongside complementary data from other sources. Through data analysis, students explore limitations, uncover patterns, and solve problems.Expand your data scope beyond your school. In this study, we compare results to and adopt methods from other studies. We found that our results are consistent with other studies.

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