**Assessment of Water Quality and Ecological Functions of Urban Wetlands at the AIT Campus, Thailand.**

# ABSTRACT

Wetlands play a vital role in urban ecosystems by offering critical services such as water purification, nutrient cycling, biodiversity support, and carbon sequestration. This study aimed to characterize the physico-chemical and microbiological water quality of selected wetlands at the Asian Institute of Technology (AIT) campus in Thailand, from November 2016–March 2017. Seven wetlands were sampled using the Standard Method. Dissolved Oxygen (DO), pH, Turbidity, Electrical Conductivity (EC), Ammonia-Nitrogen (NH₃-N), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), Chemical Oxygen Demand (COD), Chlorophyll a, and *Escherichia coli* (*E. coli*) were analysed. Additional analyses included sediment and macrophyte carbon sequestration, algal diversity, and zooplankton (rotifer) density. The results revealed slightly alkaline pH (7.5-8.3) and moderate to high DO levels (3.4–8.5 mg/L). SV1 and Chiang Rak ponds exhibited elevated turbidity (12.9–16.7 NTU), nutrient enrichment (e.g., NH₃-N at 3.4 mg/L, TKN at 4.48 mg/L), and critical *E. coli* contamination (up to 7,420 MPN/100 mL). High chlorophyll a levels were recorded in SV2 (195 µg/L) and Chiang Rak (928 µg/L). Rotifer density varied across sites, with the highest in Fountain Pond (280 ± 43 individuals/L), corresponding with improved microbial quality. Carbon sequestration was substantial in macrophyte biomass (e.g., SV2: 9.4 ± 0.5 g C m² month¹) and sediments (e.g., WD Pond: 6.6 ± 0.7 g C m² month¹). The findings suggest that while the AIT wetlands offer considerable ecological services, certain sites risk pollution and require improved management to enhance their sustainability and ecosystem functions.

**Keyword**: Biodiversity assessment, carbon sequestration, physico-chemical analysis, microbiological contamination, urban ecosystem services, wetland water quality

# 1. INTRODUCTION

Marshes, rivers, ponds, canals, and artificial wetlands are examples of wetland ecosystems that provide benefits to human society, such as nutrient retention, flood control, and water purification. However, the benefits of these services are sometimes difficult to express to decision-making authorities and to quantify. Consequently, policies and choices pertaining to wetland management and usage frequently fail to take these ecological services into account (Zohoorian-Pordel et al., 2017). Natural green and blue spaces, such as ponds and trees, are a part of urban ecosystems. In order to prevent floods and nutrient retention, urban wetlands are typically built to act as a buffer for water gushes following rainfall. They potentially support several ecosystem services and values (Nikodinoska et al., 2018). According to Li et al. (2017), urban wetlands have been shown to improve surface water quality and decontaminate rainfall runoff in towns and cities by removing solids, heavy metals, and nutrients (P, N). Man-made wetlands are intended to be reliable wastewater purification systems that also offer animals and other species acceptable habitats (Sharma and Naik, 2024). Many water birds have found a home in Melbourne's built urban wetlands, which are used for both aesthetic and stormwater treatment purposes (Sharma and Naik, 2024).

Physico-chemical parameters such as pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), Turbidity, Total Dissolved Solids (TDS), and nutrient concentrations (e.g., nitrates and phosphates) are commonly used indicators of water quality in wetlands (Nayar, 2020; Jaffar et al., 2020). These parameters influence the biochemical processes within wetlands and help determine their capacity to support various forms of life. For instance, elevated levels of nutrients can lead to eutrophication, resulting in algal blooms and oxygen depletion that threaten aquatic biodiversity (Kumar et al., 2022). Similarly, microbiological indicators, especially the presence of fecal coliforms and Escherichia coli, are essential for assessing the sanitary quality of water, particularly in wetlands that may receive domestic or stormwater runoff (Nica-Badea and Tataru, 2023). According to research by Pragasan and Gomathi (2024), all study locations had values of 17 physicochemical parameters, apart from sodium, nitrate, and sulphate, that were higher than the WHO-recommended pollution thresholds. Except for Fe and Pb, the concentration of ten heavy metal elements was found to be within acceptable bounds of the WHO-recommended standards for drinking water in all lakes. The F-test showed that, except for the pH (P =.749), the concentration of all physicochemical parameters varied significantly across all study sites.

Ecosystem services are goods and services humans obtain from the ecosystem (Brown et al., 2007). Apart from tangible benefits, wetlands also provide important intangible, non-material, spiritual, and cultural services (Brander et al., 2024). Quantification of ecosystem services evaluates the gains of the benefits obtained by individuals from ecosystems. It consists of a broad horizon of techniques and is executed through various methods with other tools. Quantification of ecosystem Services has been employed as a tool to provide information to support ecosystem management (Torres and Hanley, 2017). The quantification of ecosystem services involves measurement of biophysical outcomes, measurement of how the biophysical outcomes affect the quantity and quality of ecosystem goods and services, and economic valuation of those ecosystem goods and services (Scarlett and Boyd, 2015). Mukhtar (2015) studied “Ecological Engineering for Sustainable Asian Institute of Technology (AIT) Eco-campus: Diversification of Wetland Eco-Services via Water Quality-Biodiversity Nexus,” identified actual and potential services provided by the AIT wetlands, but did not quantify them to provide information or data that will help to manage wetlands on the AIT campus. This study, therefore, aims to characterize the water quality of wetlands at the AIT Campus by analyzing selected physico-chemical and microbiological parameters to assess the current status and identify potential threats to ecosystem health and public safety.

# 2. METHODOLOGY

**Study area**

Wetland systems on the campus of the Asian Institute of Technology (AIT) were the subject of the investigation. In Khlong Luang-Pathumthani, Thailand, there is an international university called AIT. With coordinates of 14° 04′ 46.00′′ N, 100° 36′ 50.51′′ E, the campus is located in Bangkok, some 40 kilometers north of the country's center. Since its founding in 1959, AIT has focused on engineering, innovative technologies, planning, and management. Approximately 3,000 people live on the campus, which occupies 1.28 km². The average annual temperature is between 25 and 33 °C, and the average annual precipitation is 1648 millimeters (Thai Meteorological Department, 2015).

**Water sample collection and analysis**

The methods described in the Standard Method (APHA, 2005) served as the foundation for the sampling and analysis of water. The study employed a stratified sample methodology (US/EPA, 2002). In order to facilitate sampling, the seven wetlands included in the study, Fountain Pond, W Dorm Pond, SV1 Pond, SV2 Pond, Library Pond, Library Canal, and West Lake, were further separated into fifteen layers. Depending on the analysis, sampling occurred every two weeks or every month (Table 1). Between November 2016 and March 2017, samples were collected.

Turbidity, pH, Electrical Conductivity, Dissolved Oxygen (DO), Nitrogen, Total Kjeldahl Nitrogen (TKN), Total Phosphorus, Chemical Oxygen Demand, Chlorophyll a, and *Escherichia coli* were among the physico-chemical and microbiological characteristics of wetland water that were examined. Following normal protocols, the water samples for examination were gathered in clean plastic bottles and examined at the AIT Environmental Engineering and Management Laboratory. Standard Methods for Examination of Water and Wastewater was the approach used for the analysis. The analysis was conducted using the following techniques: turbidity, pH, electrical conductivity, and dissolved oxygen were measured using turbidity, pH, and conductivity meters, respectively. Total Kjeldahl and the Titrimetric Method were used to assess nitrogen. The Kjeldahl technique was used to determine nitrogen, while the Persulphate technique was used to quantify total phosphorus. A compound microscope was used to identify the algae species, and the trichromatic method was used to assess the chlorophyll a.

**Table 1: Sampling Intervals for Parameters Studied**

|  |  |
| --- | --- |
| Parameter | Frequency |
| Turbidity, EC, DO, pH, Water Temperature | Twice a month |
| NH3-N, TKN, TP | Twice a month |
| COD, Chlorophyll a*, E. coli,* Algal species identification | Once a month |
| Organic Carbon (OC) | Once a month |

**Analysis of sediment for the determination of carbon**

Using the Peterson grab sampler (Pan et al., 2017), three non-disturbed sediment samples were collected from the bottom below the water of the Fountain Ponds system, SV1 Pond, SV2 Pond, and WD Pond sampling points. The samples were then put into labeled containers and sent to the AIT Environmental Engineering and Management laboratory for analysis.



**Figure 1**: Sediment sampling using the Peterson grab sampler

Using the Loss-on-ignition technique, sediment samples were examined for moisture content and Organic Carbon (OC) (Piper, 1944, quoted in Avasarala, 2021). 40 g of wet sediment was transferred into crucibles for moisture and carbon measurement after the samples had been manually combined to create a homogenous sample. To ascertain the moisture content, each crucible sample was weighed, dried for 24 hours at 105° C, and then weighed once again. Following a 24-hour drying period at 550° C in a muffle furnace, samples were immediately burned and weighed once again to calculate the mass lost upon ignition. Using the method and relationship described by Percival (2017), the amount of organic matter was calculated and transformed into organic carbon. (Refer to equations I, II, and III for the determination of moisture content, organic matter, and organic carbon, respectively).

Moisture content (%) = Weight of moist sediment (g)-Weight of dry sediment (g) --- I

Weight of dry sediment (g)

Organic Matter (%OM) = Sediment weight at 105°C – Sediment weight at 550° C --- II

Sediment weight at 550° C

Organic Carbon (% OC) = Organic Matter (%OC) --------------------------------- III

1.72

**Analysis of macrophytes for the determination of carbon**

Each sampling site's quadrat (1 m2) was used to collect macrophyte samples (Dotro et al., 2017). For the purpose of analyzing organic carbon, stems, leaves, and root biomass were removed from the quadrat, stored in a plastic bag, and brought to the AIT Environmental Engineering and Management lab. After being wrapped, the biomass was oven-dried for 48 hours at 80 °C. Using the Walkley-Black technique (Avramidis et al., 2015) (equation IV for the estimate of organic carbon), dried biomass was pulverized, sieved, and examined for organic carbon.

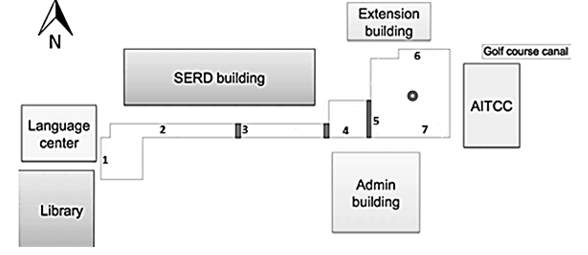
% Organic carbon = (mL K2Cr2O7 – mL FeSO4) 0.003 \* 100 \* 1.33 ------------------------- IV.

Soil weight

**Analysis of algal/cyanobacterial species**

A compound microscope with a 100x magnification was used to study the algae species (APHA, 2005). The influence of macrophytes on the disappearance of algae/cyanobacteria (*Spirulina* sp.) in AIT wetlands (Fountain pond) was evaluated by taking into account the diversity of algal species in connection with water quality.

According to standard protocol (McCarthy et al., 2011), the AIT fountain-library pond system was split up into seven sample locations. For identification purposes, sample containers were initially labeled with the date, time, and sampling location. From every sampling location within 0.3 meters of the water's depth, surface grab samples were taken (Figure 2). At the appropriate sample depth, the sampling container was gradually lowered into the water. The filled container was swiftly brought back to the surface, sealed, and secured. Algal mats or the scum layer were gathered, examined, and interpreted independently. The average concentration throughout time or space was determined by averaging the concentrations of the various grab samples. Figure 2 illustrates the sampling procedure for the AIT fountain pond (LP), library canal (LC), and library pond (LP).



**FP**P

**LP**

**LC**

**Figure 2:** Sampling points in the fountain pond (FP), library canal (LC), and library pond (LP)

**Analysis of zooplankton (Rotifers)**

Rotifers were identified and analyzed using the Standard Operating Procedure for Zooplankton Analysis (US/EPA, 1994). The original 1000 mL sample was split up into 125 mL. A sample of 1 mL was extracted from 125 mL for analysis and computation in a rotifer. Rotifers were inspected using Sedgwick-Rafter cell slides under a compound microscope with a 100x (100 times) magnification. Rotifer was recorded in samples that were subdivided. Rotifer density was indicated by the computed mean of three replications.

# 3. RESULTS

The physico-chemical and microbiological characterization was done to provide data that would support the quantification of wastewater treatments benefits and carbon sequestration service of AIT wetland systems (Fountain Pond (FP), Student Village I & II Pond (SV1-2), W Dorm pond (WD), Library pond (LP), Library Canal (LC), West Lake (WL), Chiang Rak (CR).

**Physico-chemical and microbiological** **characterization of wetland water quality**

The results of the current water quality (physico-chemical and microbiological analysis) of AIT wetlands studied are presented in Tables 2, 3, and 4. The lowest pH value was 7.5 ± 0.1, and the highest was 8.3 ± 0.1, indicating all the wetland water was within a slightly alkaline medium. Dissolved oxygen (DO) ranged between 5.3 ± 0.1mg/L and 8.5 ± 0.3mg/L in all selected wetlands above, while turbidity values were between 5.7 ± 0.4 NTU and 16.7 ± 0.4 (Table 2). Electrical conductivity (EC) varied from 570 ± 9 µs/cm to 1137 ± 170 µs/cm while wetland water temperature ranged from 25.1 ± 0.4 to 28.7 ± 0.9 (Table 2). Chemical water quality analysis targeted on NH3-N, TKN, TP, COD, and chlorophyll a (Table 3), whereas microbiological parameters considered were *E. coli* counts (Table 4).

**Table 2: Current AIT Wetland Water Quality Based on Physical Analysis**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AIT Wetlands** | **pH** | **DO**  **(mg/l)** | **Turbidity**  **(NTU)** | **EC**  **(µs/cm)** | **Temp**  **(OC)** |
| FP | 7.6 ± 0.1 | 5.3 ± 0.1 | 5.7 ± 0.4 | 721 ± 7 | 25.1 ± 0.4 |
| SVI | 7.5 ± 0.1 | 3.4 ± 0.4 | 12.9 ± 0.6 | 570 ± 9 | 25.2 ± 0.4 |
| SV2 | 7.7 ± 0.1 | 5.0 ± 0.3 | 14.5 ± 0.6 | 573 ± 40 | 25.3 ± 0.7 |
| WD | 7.7 ± 0.1 | 4.9 ± 0.4 | 4.4 ± 0.2 | 725 ± 7 | 25.4 ± 0.3 |
| LP | 8.1 ± 0.2 | 4.6 ± 0.1 | 4.1 ± 0.3 | 1,137 ± 170 | 28.7 ± 0.9 |
| LC | 8.3 ± 0.1 | 3.4 ± 0.1 | 4.0 ± 0.1 | 1,068 ± 259 | 25.5 ± 0.8 |
| WL | 7.8 ± 0.2 | 6.0 ± 0.2 | 5.2 ± 0.2 | 923 ± 158 | 25.5 ± 0.3 |
| CR | 8.2 ± 0.1 | 8.5 ± 0.3 | 16.7 ± 0.4 | 761±15 | 27.4±0.5 |

**Table 3: Current AIT Wetland Water Quality Based on Chemical Analysis**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AIT Wetlands** | **NH3-N**  **(mg/L)** | **TKN**  **(mg/L)** | **TP**  **(mg/L)** | **COD**  **(mg/L)** | **Chlorophyll a**  **(µg/L)** |
| FP | 0.08 ± 0.01 | 0.44 ± 0.2 | 0.16 ± 0.03 | 42 ± 12 | 67 ± 2.0 |
| SVI | 0.46 ± 0.10 | 1.9 ± 0.30 | 0.40 ± 0.04 | 90 ± 19 | 28 ± 4 |
| SV2 | 0.61 ± 0.20 | 1.7 ± 0.20 | 0.29 ± 0.04 | 78 ± 18 | 195 ± 26 |
| WD | 0.30 ± 0.10 | 0.80 ± 0.20 | 0.24 ± 0.03 | 53 ± 13 | 77 ± 5 |
| LP | 0.47 ± 0.13 | 1.0 ± 0.30 | 0.28 ± 0.05 | 61 ± 8 | 167 ± 3 |
| LC | 0.14 ± 0.03 | 0.54 ± 0.20 | 0.19 ± 0.03 | 45 ± 21 | 62 ± 2 |
| WL | 0.15 ± 0.04 | 0.50 ± 0.20 | 0.16 ± 0.03 | 40 ± 7 | 82 ± 4 |
| CR | 3.4 ± 0.01 | 4.48 ± 0.20 | 0.75 ± 0.02 | 90 ± 15 | 928 ± 22 |

Dissolved Oxygen concentrations measured between 6:00 AM and 8:00 PM showed differences for both Fountain and SV1 ponds. The highest DO values of 6.8 mg/L and 5.0 mg/L were noticed at 4:00 PM in Fountain and SV1 ponds, respectively. While the respective lowest DO values of 0.51mg/L and 0.42 mg/L were observed at 6:00 AM (Figure 3).

**Figure 3: Diurnal variation of dissolved oxygen (DO) in the fountain and SV1 ponds**

Lowest values of pH were 6.3 and 7.0 noticed at 8:00 AM for Fountain and SV1 ponds, respectively, and the highest values of 8.0 and 7.9 were experienced at 4:00 PM (Figure 4). The comparatively high pH value could be due to a high level of alkalinity rising from microalgae photosynthesis, which was invariably high at 4:00 AM.

**Figure 4: Diurnal variation of pH in the fountain and SV1 ponds**

**Table 4: Current AIT Wetland Water Quality Based on Microbiological Analysis**

|  |  |
| --- | --- |
| **AIT Wetlands** | ***E. coli* (MPN/100mL)** |
| Fountain Pond (FP) | 728 ± 80 |
| Student Village 1 Pond (SV1) | 4,498 ± 229 |
| Student Village 2 Pond (SV2) | 1,701 ± 253 |
| W Dorm Pond (WD) | 669 ± 108 |
| Library Pond (LP) | 668 ± 47 |
| Library Canal (LC) | 71 ± 10 |
| West Lake (WL) | - |
| Chiang Rak Pond | 7420 |

***E. coli* reduction in AIT wetlands**

Variations of *Escherichia coli (E. coli)* concentration during the study period are presented in Figure 5 SV1 Pond had the highest *E. coli* concentration throughout the study period. The *E. coli* concentrations in all the wetlands kept fluctuating monthly, but SV1 Pond recorded the highest *E. coli* concentration in the 12th week, indicating high sewage contamination in SV1 Pond.

**Figure 5: Weekly variations of *E. coli* concentration in AIT wetlands (November 2016-March 2017)**

**Sediment analysis for carbon**

The detailed results of monthly sediment carbon storage of the Fountain Pond system, SV1 Pond, SV2 Pond, and WD Pond are presented in Table 5; monthly carbon storage of each above wetlands within the period of analysis was not significantly different (p >0.05) from each other. However, the average monthly carbon stored among the wetlands was observed to be highly significant (p <0.001), indicating that WD Pond sequestered significantly more carbon than the others due to its greater macrophyte coverage and sediment stability over the study period, with WD Pond recording the highest amount of carbon of 6.6 ± 0.7 g C m-2 month-1. The total sediment sequestration of the selected wetlands was measured as 14.6 ± 1.6 g Cm-2 month-1 (175.2 ± 19.2 g Cm-2 year-1).

**Table 5: Monthly Wetland Sediment Carbon**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Wetland Types** | **Monthly carbon sequestration (g Cm-2 month-1)** | | | |
| **November** | **December** | **January** | **Mean** |
| Fountain pond system | 3.3 ± 0.1 | 2.8 ± 0.1 | 3.1 ± 0.4 | 3.0 ± 0.2 |
| SV1 pond | 1.5 ± 0.2 | 1.7 ± 0.3 | 1.5 ± 0.3 | 1.6 ± 0.2 |
| SV2 pond | 3.4 ± 0. 5 | 3.4 ± 0.7 | 3.3 ± 0.2 | 3.4 ± 0.5 |
| WD pond | 6.9 ± 0.5 | 6.1 ± 0.6 | 6.6 ± 1.0 | 3.6 ± 0.7 |

**Macrophytes analysis for carbon**

The results of the AIT wetland macrophytes carbon are shown in Table 6. Macrophytes carbon among the Fountain Pond, SV2 Pond, and WD Pond was significant (p < 0.001), supporting the inference that SV2 Pond's higher macrophyte biomass led to greater carbon accumulation when compared to Fountain and WD ponds with SV2 Pond recording the highest mean value of 9.4 ± 0.5 g C m-2 month-1. The total macrophytes carbon of the selected wetlands throughout the study was 25.7 ± 1.5 g Cm-2 month-1 (308.4 ± 18 g Cm-2 year-1).

**Table 6: Monthly Wetland Macrophytes Carbon**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Wetland Types** | **Monthly carbon sequestration (g Cm-2 month-1)** | | | |
| **November** | **December** | **January** | **Mean** |
| Fountain pond system | 7.3 ± 0.5 | 7.1 ± 0.8 | 6.7 ± 0.6 | 7.0 ± 0.6 |
| SV2 pond | 9.8 ± 0.6 | 9.7 ± 0.2 | 8.9 ± 0.8 | 9.4 ± 0.5 |
| WD pond | 9.8 ± 0.5 | 8.9 ± 0.3 | 9.3 ± 0.3 | 9.3 ± 0.4 |

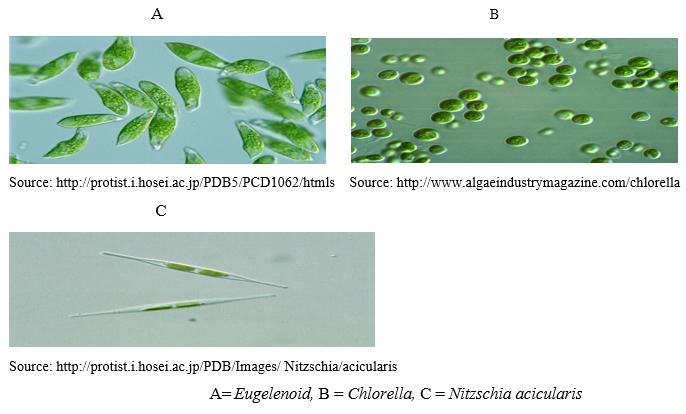
**Algae species analysis**

Table 7 displays the findings of an analysis of the population of algae species in the chosen wetlands, expressed as a percentage (%) of all microalgae species in the sample. Fountain ponds had the greatest diversity of species, but other ponds (wetlands) had fewer species. The most prevalent species were *Nitzschia, diatoms, chlorella,* and *euglenoids*. Marginal varieties found were *Scenedesmus sp., Selenastrum sp., Merismopedia, Actinastrum,* and *Ankistrodesmus sp*.

Analysis showed that *Euglenoids* were the main genus of *Chlorophyta* (green algae) in all AIT wetlands. *Cyanobacteria* (‘blue green algae’) like *Spirulina sp* were not found. Species of algae identified are demonstrated in Figure 6.

**Table 7: Algae Diversity and Chlorophyll a Concentrations**

|  |  |  |  |
| --- | --- | --- | --- |
| **AIT Wetlands** | **Algae Diversity** | **Concentration of algae species (%)** | **Chlorophyll a (µg/L)** |
| Fountain Pond | *Chlorella*  *Filamentous diatom*  Eugelenoids  *Nitzschia* | 5 ± 0  10 ± 0  75 ± 0  15 ± 1 | 67 ± 2.0 |
| SV1 Pond | *Filamentous diatoms*  Eugelenoid  *Nitzschia* | 50 ± 3  29 ± 4  6 ± 2 | 28 ± 4 |
| SV2 Pond | *Filamentous diatom*  Euglenoid  *Nitzschia* | 21 ± 4  74 ± 10  3 ± 1 | 195 ± 26 |
| WD Pond | *Filamentous diatom*  Euglenoid | 21 ± 6  70 ± 3 | 77 ± 5 |
| Library Pond | *Chlorella*  *Filamentous diatom*  Euglenoids | 28 ± 10  13 ± 3  72 ± 2 | 167 ± 3 |
| Library Canal | *Chlorella*  *Filamentous diatom*  Euglenoids | 5 ± 2  6 ± 0  74 ± 0 | 62 ± 2 |
| West Lake | *Chlorella*  *Filamentous diatom*  Euglenoids | 3 ± 2  18 ± 10  70 ± 4 | 82 ± 4 |

****

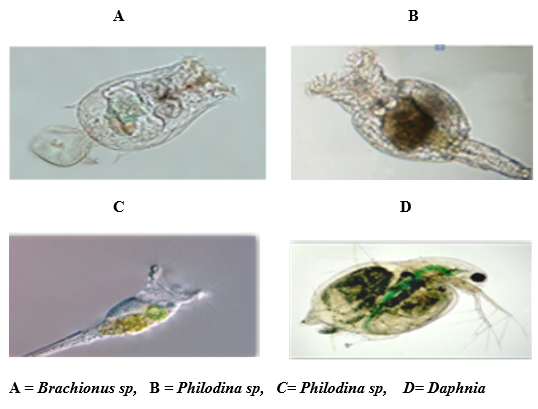
**Figure 6: Species of algae diversity identified in AIT wetlands**

**Zooplankton (rotifer) analysis**

Table 8 presents the average rotifer density over the research period, with the fountain pond having the most rotifers. While rotifers and a small number of daphnia were seen in Chiang Rak Pond, they were only found in the AIT wetlands. West Lake had the lowest concentration, 46 ± 16 Individual/L, whereas Fountain Pond had the highest mean, 280 ± 43 Individual/L. Figure 7 displays several kinds of zooplankton that have been identified.

**Table 8: Rotifer Density in AIT Wetlands**

|  |  |
| --- | --- |
| **AIT Wetlands** | **Rotifer Individual/L** |
| Fountain Pond (FP) | 280 ± 43 |
| Student Village 1 Pond (SV1) | 200 ± 54 |
| Student Village 2 Pond (SV2) | 160 ± 57 |
| W Dormitory Pond (WD) | 140 ± 49 |
| Library Pond (LP) | 213 ± 55 |
| Library Canal (LC) | 138 ± 28 |
| West Lake (WL) | 46 ± 16 |
| Chiang Rak Pond | 50 ± 12 |



**Figure 7:** Species of zooplankton identified in AIT wetlands using compound light microscope

**Dissolved Oxygen (DO) and pH effect on rotifer (zooplankton)**

The effects of DO and pH on zooplankton growth and density are depicted in Figures 8 and 9. A slightly alkaline pH of 7.2 affects rotifer density (350 Individual/L) in AIT Wetlands. A high alkaline pH (>7.9) reduced the density of rotifers (150 Individual/L) (Figure 8). A low dissolved oxygen level reduced the rotifer concentrations in the AIT Wetland. When the DO level exceeds 5.3 mg/L, the density of rotifers (350 individuals/L) is impacted. Table 9 shows the average rotifer density, dissolved oxygen, and pH of AIT wetlands. Water quality has improved in a fountain pond with a high concentration of rotifers (280 ± 43) because it reported lower mean *E. coli* counts (728 ± 80 MPN/100 mL) and chlorophyll a concentrations (67 ± 2.0 µg/L).

**Table 9: Mean DO, pH, and Rotifers Concentrations**

|  |  |  |  |
| --- | --- | --- | --- |
| **AIT Wetlands** | **pH** | **DO (mg/L)** | **Rotifer (Individual/L)** |
| FP | 7.6 ± 0.1 | 5.3 ± 0.1 | 280 ± 43 |
| SVI | 7.5± 0.1 | 3.4 ± 0.4 | 200 ± 54 |
| SV2 | 7.7 ± 0.1 | 5.0 ± 0.3 | 160 ± 57 |
| WD | 7.7± 0.1 | 4.9 ± 0.4 | 140 ± 49 |
| LP | 8.1± 0.2 | 4.6 ± 0.1 | 213 ± 55 |
| LC | 8.3± 0.1 | 3.4 ± 0.1 | 138 ± 28 |
| WL | 7.8 ± 0.2 | 6.0 ± 0.2 | 46 ± 16 |

**Figure 8:** Effect of pH on rotifer density in AIT wetlands

**Figure 9:** Effect of DO on rotifer density in AIT wetlands

# 4. DISCUSSION

Dissolved oxygen concentrations in Fountain and SV1 Pond were higher in daytime than nighttime or early hours of the day (Figure 1). This indicates that absence of sun energy, photosynthesis will not occur, and thus, microalgae have little or no effect on Dissolved Oxygen in the pond at night. It was discovered that the DO levels in SV1 Pond were marginally greater than those in Fountain Pond throughout the night, when algal photosynthesis was not occurring (Figure 1). In general, a rise in water temperature limits the amount of dissolved oxygen in ponds. The maximum values found were less than those found by Liu et al. (2022), who found that a high algal pond had a DO of 11.46 mg/L. But for a less algal pond, Shiba et al. (2021) recorded the highest (DO - 7.59 mg/L), which is comparable to the Fountain pond's. The large variation in the maximum DO levels among the ponds mentioned above may be caused by variations in the species and algae densities found there. DO levels, although generally within acceptable limits, exhibited diurnal variations, with lower values recorded in the early morning due to the natural cycle of photosynthesis and respiration. This finding is consistent with El Hawary and Shaban (2018), who identified similar patterns in urban wetland environments.

Figures 8 and 9 show how dissolved oxygen and pH affect rotifer density. In AIT Wetlands, a slightly alkaline pH of 7.2 affected rotifer density (350 individuals/L). The rise in alkalinity brought on by algal photosynthesis, which peaked around 4:00 AM, may be the cause of the Fountain pond's high pH level (Figure 3). The comparatively high pH value could be due to a high level of alkalinity resulting from microalgae photosynthesis, which typically increases during the day due to CO₂ uptake and hydroxide ion release supported by El Hawary and Shaban (2018) and Reddy et al. (2022). Rotifer density (150 individuals/L) was decreased by high alkaline pH (>7.9) (Figure 8). Rotifer concentrations in the AIT Wetland were decreased by low dissolved oxygen levels. Rotifer density (350 individuals/L) is influenced by dissolved oxygen levels over 5.3 mg/L. According to Reddy et al. (2022), zooplankton diversity and populations are increased when water bodies are improved to maintain a high amount of dissolved oxygen.

The amount of chlorophyll a, or algae biomass, in AIT wetlands is correlated with the levels of phosphorus and nitrogen in the wetlands. According to the study, high levels of phosphorus and nitrogen in SV1 Pond, SV2 Pond, and Chaing Rak Pond resulted in high algal biomass (Table 3). High quantities of Spirulina sp. were found in the Chaing Rak pond with high N and P levels (3.4 ± 0.01 and 0.75 ± 0.02). According to Richardson et al. (2018), phosphorus and nitrogen are the best helping variables for cyanobacteria predominance in wetlands. The best way to prevent cyanobacteria blooms in wetlands is to reduce phosphorus pollution in conjunction with a healthy food web structure system (a good zooplankton-plankton ratio) (Burford et al., 2019).

After being tainted with N, P, *E. coli*, and chlorophyll a in 2015, Fountain Pond (FP) and Library Pond (LP) currently show significant recovery, with turbidity levels ranging from 39.6 to 46.2 NTU. In the Fountain Pond, *E. coli* dropped from 1073 400MPN/100mL to 400MPN/100m/L. The concentration of *E. coli* in the SV1 Pond without macrophytes did not alter (Zhou et al., 2025). An established method of evaluating the quality of water in terms of algal biomass is to measure the concentration of chlorophyll a (Sadeghian et al., 2018). Algal biomass and low water quality are seen in wetlands with high levels of chlorophyll a. The water quality was worse in SV2 Pond and Chiang Rak Pond, which had high concentrations of chlorophyll a (195 ± 26 µg/L and 928 ± 22 µg/L). Because *E. coli* cannot thrive in cold-blooded species like fish and is only linked to warm-blooded creatures like humans and birds, the presence of fish in water bodies does not affect the amount of *E. coli* present (Mazengia et al., 2024; Petersen and Hubbart, 2020). Fountain Pond and Library Pond were classified as hyper-eutrophic wetlands in 2015 for turbidity (25–50 NTU) and TP (<0.035–0.1 mg/L) according to wetland water quality criteria (Chapman, 2021).

# 5. CONCLUSION

The study demonstrates that the AIT campus wetlands provide vital ecological functions such as water purification, biodiversity support, and carbon sequestration, with generally favorable physico-chemical conditions and significant organic carbon storage. However, variations in water quality, particularly elevated nutrient levels, turbidity, and *E. coli* contamination in some sites, highlight localized pollution challenges likely stemming from urban runoff and inadequate wastewater management. The diversity of algal species and rotifer populations further indicates differing ecological health across the wetlands. These findings underscore the need for targeted management strategies to mitigate contamination, enhance ecosystem services, and sustain the long-term ecological integrity of urban wetlands in rapidly developing environments like AIT.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

# REFERENCES

Avasarala, S. (2021). Techniques for assessing metal mobility in the environment: a geochemical perspective. *Practical Applications of Medical Geology,* 139-167. <https://doi.org/10.1007/978-3-030-53893-4_4>

Avramidis, P., Nikolaou, K., & Bekiari, V. (2015). Total organic carbon and total nitrogen in sediments and soils: A Comparison of the wet oxidation–titration method with the combustion-infrared method. *Agriculture and Agricultural Science Procedia, 4*, 425–430. <https://doi.org/10.1016/j.aaspro.2015.03.048>

Brander, L. M., De Groot, R., Schägner, J. P., Guisado-Goñi, V., Van't Hoff, V., Solomonides, S., ... and Thomas, R. (2024). Economic values for ecosystem services: A global synthesis and way forward. *Ecosystem Services, 66*, 101606. <https://doi.org/10.1016/j.ecoser.2024.101606>

Brown, T. C., Bergstrom, J. C., and Loomis, J. B. (2007). Defining, valuing, and providing ecosystem goods and services. *Natural Resources Journal*, 329-376.

Burford, M. A., Gobler, C. J., Hamilton, D. P., Visser, P. M., Lurling, M., & Codd, G. A. (2019). Solutions for managing cyanobacterial blooms: A scientific summary for policy makers.

Chapman, D. V. (2021). *Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring*. CRC Press. <https://doi.org/10.1201/9781003062103>

Dotro, G., Langergraber, G., Molle, P., Nivala, J., Puigagut, J., Stein, O., & Von Sperling, M. (2017). *Treatment wetlands* (p. 172). IWA publishing.

El Hawary, A., & Shaban, M. (2018). Improving drainage water quality: Constructed wetlands-performance assessment using multivariate and cost analysis. *Water Science, 32*(2), 301-317. <https://doi.org/10.1016/j.wsj.2018.07.001>

Jaffar, A., M Thamrin, N., Megat Ali, M. S. A., Misnan, M. F., & Mohd Yassin, A. I. (2020). The influence of physico-chemical parameters to determine water quality: A review. Journal of Electrical and Electronic Systems Research (JEESR), 17, 116-121. <https://doi.org/10.24191/jeesr.v17i1.016>

Kumar, S., Veerwal, B., Sharma, D., & Verma, B. (2022). Review on Physico-chemical Parameters of Water Concerning their Effect on Biotic Population. Indian Hydrology, 21(2), 15-24.

Li, M., Wu, H., Zhang, J., Ngo, H. H., Guo, W., and Kong, Q. (2017). Nitrogen removal and nitrous oxide emission in surface flow constructed wetlands for treating sewage treatment plant effluent: effect of C/N ratios. Bioresource Technology, 240, 157-164. https://doi.org/10.1016/j.biortech.2017.02.054

Liu, R., Li, S., Tu, Y., Hao, X., & Qiu, F. (2022). Recovery of value-added products by mining microalgae. Journal of Environmental Management, 307, 114512. <https://doi.org/10.1016/j.jenvman.2022.114512>

Mazengia, H., Kaiser, H., & Mengist, M. (2024). Physical and chemical water quality characteristics in six wetlands of Lake Tana, Ethiopia. <https://doi.org/10.21203/rs.3.rs-3993010/v1>

McCarthy, C., Suplee, M., & Sada, R. (2011). Sample collection and laboratory analysis of Chlorophyll-a standard operating procedure. *Montana Department of Environmental Quality. WQPBWQM-011*.

Mukhtar, H. (2015). Ecological Engineering for Sustainable AIT Eco-Campus: Diversification of Wetland Eco-Services via Water Quality-Biodiversity Nexus (Master Thesis No. EV-15-07, Asian Institute of Technology). Bangkok: Asian Institute of Technology.

Nayar, R. (2020). Assessment of water quality index and monitoring of pollutants by physico-chemical analysis in water bodies: a review. International Journal of Engineering Research and Technology, 9(01), 178-185. <https://doi.org/10.17577/IJERTV9IS010046>

Nica-Badea, D., & Tataru, T. (2023). Water quality and spatial assessment of physicochemical parameters. Pharmacophore, 14(5-2023), 40-47. <https://doi.org/10.51847/Q9X8bdrOZl>

Nikodinoska, N., Paletto, A., Pastorella, F., Granvik, M., and Franzese, P. P. (2018). Assessing, valuing and mapping ecosystem services at city level: The case of Uppsala (Sweden). Ecological Modelling, 368, 411-424. <https://doi.org/10.1016/j.ecolmodel.2017.10.013>

Pan, X., Helgason, W., Ireson, A., & Wheater, H. (2017). Field-scale water balance closure in seasonally frozen conditions. Hydrology and Earth System Sciences, 21(11), 5401-5413. <https://doi.org/10.5194/hess-21-5401-2017>

Percival, J. B. (2017). Measurement of physical properties of sediments. In Manual of physico-chemical analysis of aquatic sediments (pp. 7-45). Routledge. <https://doi.org/10.1201/9780203748176-2>

Petersen, F., & Hubbart, J. A. (2020). Physical factors impacting the survival and occurrence of Escherichia coli in secondary habitats. Water, 12(6), 1796. <https://doi.org/10.3390/w12061796>

Pragasan, L. A., & Gomathi, T. (2024). Water quality and environmental health of lakes in Coimbatore, India: A comprehensive study of the physicochemical characteristics. Asian Journal of Environment & Ecology, 23(7), 11-24. <https://doi.org/10.9734/ajee/2024/v23i7560>

Reddy, K. R., DeLaune, R. D., & Inglett, P. W. (2022). Biogeochemistry of wetlands: science and applications. CRC Press. <https://doi.org/10.1201/9780429155833>

Richardson, J., Miller, C., Maberly, S. C., Taylor, P., Globevnik, L., Hunter, P., ... & Carvalho, L. (2018). Effects of multiple stressors on cyanobacteria abundance vary with lake type. Global Change Biology, 24(11), 5044-5055. <https://doi.org/10.1111/gcb.14396>

Sadeghian, A., Chapra, S. C., Hudson, J., Wheater, H., & Lindenschmidt, K. E. (2018). Improving in-lake water quality modeling using variable chlorophyll a/algal biomass ratios. Environmental Modelling & Software, 101, 73-85. <https://doi.org/10.1016/j.envsoft.2017.12.009>

Scarlett, L., and Boyd, J. (2015). Ecosystem services and resource management: institutional issues, challenges, and opportunities in the public sector. Ecological Economics, 115, 3-10. <https://doi.org/10.1016/j.ecolecon.2013.09.013>

Sharma, L. K., and Naik, R. (2024). Wetland Ecosystems. In Conservation of Saline Wetland Ecosystems: An Initiative towards UN Decade of Ecological Restoration (pp. 3-32). Singapore: Springer Nature Singapore. <https://doi.org/10.1007/978-981-97-5069-6_1>

Shiba, A. S. E., Ali, M. N., Mohamed, S. A., Mahmoud, R. S., & Naguib, A. (2021). Supporting Eco-Cities by Utilizing Green Technologies in Wetlands for On-Site Wastewater Treatment. Design Engineering, (3), 940-954.

Torres, C., and Hanley, N. (2017). Communicating research on the economic valuation of coastal and marine ecosystem services. Marine Policy, 75, 99-107. <https://doi.org/10.1016/j.marpol.2016.10.017>

Zhou, T., Yang, X., Cai, S., Yang, Q., Zhang, W., Li, Z., & Ran, L. (2025). Long-term monitoring of total suspended matter concentration in fishponds in the Guangdong-Hong Kong-Macao Greater Bay Area. Environmental Monitoring and Assessment, 197(2), 1-24. <https://doi.org/10.1007/s10661-024-13548-4>

Zohoorian-Pordel, M., Bornaa, R., Neisi, H., Eslamian, S., Ostad-Ali-Askari, K., Singh, V. P., ... and Matouq, M. (2017). Assessment of anthropogenic influences on the micro-climate of wetland ecosystems: the case of Hoor-Alazim Wetland in Iran. Int J Min Sci, 3(2), 34-51. <https://doi.org/10.20431/2454-9460.0304004>