USING OF MACRO-AQUATIC INSECTS IN WATER QUALITY ASSESSMENT OF TAUNGTHAMAN LAKE, AMARAPURA TOWNSHIP, MANDALAY REGION

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Abstract

An investigation using macro-aquatic insects in water quality assessment was carried out at Taungthaman Lake, during July 2019 to June 2020. The specimen collection was conducted using D-framed net by drifting method. A total of 3196 individuals of 30 species, belonging to 29 genera, 21 families under nine orders were recorded. The water quality was assessed as fairly poor in the studied lake. The highest degradation of water quality (BI) was (7.34) examined at Site I in cold season, and the lowest degradation (BI) was (6.67) at Site II in rainy season. Nowadays, Taungthaman Lake is important to maintain the healthy water body because human invaded and utilized the land for settlement around the lake. The lake water was disturbed by the human activities. Thus, the water quality was degraded to unusable condition.

Keywords Water quality, aquatic insects, Taungthaman Lake.

Introduction

Aquatic insects involved on land and then evolved to water (Ward, 1992). About 45,000 insect species are known to diverse freshwater ecosystem (Balaram, 2005). Aquatic insects are one of the important components for food web in freshwater ecosystem (Resh and Rosengerg, 1984). In the food web of Lake ecosystem, aquatic insects are the main prey of nekton and have a role as decomposer of organic matter (Bouchard, 2004; Choudhury and Gupta, 2015).

Aquatic insects serve as reliable indicators of ecological characteristics of water. Some aquatic insect families such as Ephemeroptera, Plecoptera, Tricoptera, Diptera, etc., may serve as good indicators of water pollution; and have been used in fresh water bio-monitoring and assessment of environmental impacts (Arimoro and Lkomi, 2008). They also played an important role in removing nutrients from the polluted waters (Resh and Rosenberg, 1984). When insects emerge from the water as adults, they remove some of the nutrients that were in the water, they remove 1-14% of Phosphorus and 1-10% of Nitrogen from the water (Resh and Rosenberg, 1984). They have population fluctuation and this character is mainly related to seasonal inundation (Hamilton, 2002; Mayora *et al.,* 2013).

Taungthaman Lake is located in Amarapura Township, Mandalay Region. Tropical floodplain plays a significant role in providing highly productive ecosystem services (Pettit *et al.,* 2011), vital to a range of ecosystem processes (Hamilton, 2002). However, industrial and domestic waste discharge (Azrina *et al.,* 2006) often contributes to river water quality deterioration in the tropical regions (Harun *et al.,* 2015). By knowing some of the important factors in aquatic insect fatalities, people will be more able to solve pollution problems of lake to keep the insects from dying out forever. Thus, Taungthaman Lake is selected to conduct a research work; with the objectives to record the occurrence of aquatic insects and to make assessment of water quality at Taungthaman Lake.

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Materials and Methods

Study area and study sites

The study was conducted in Taungthaman Lake. Taungthaman Lake is situated in Amarapura Township of Mandalay Region. It lies between 21° 53′ N to 21° 54′ N latitude and 96° 03′ E to 96° 05′ E longitude (Fig.1) and it covers an area of about 495 km^2. The climate of the study area is characterized by three seasons: hot season (March - June), rainy season (July - October) and cold season (November - February). Two study sites were allocated as Southern part (Site I), it is deep area of lake and Northern part (Site II), which is related with inlet channel from downtown.

Figure 1 A map of study area and study sites (Source: Google earth, 25-11-2020)

Data collection

Study period was from July 2019 to June 2020. The specimens were collected in the morning from 8:00 am to 10:00 am at the littoral zone of each study site. The study sites were visited every month in the study period. The collection was undertaken using D-framed net by drifting method. The net opening is 35 cm wide and 25 cm deep. Once drifting, it takes two minutes and three times in each study site. After drifting, examine, wash and discharged large pieces of plant, woody debris, stones, making sure to retain any aquatic insects observed.

Identification of species

Collected specimens were identified and classified followed after Garrison *et al.* (2006), Easton *et al*. (2012). Koh (1989), Subramanian and Sivaramakrishnan (2007), Verma (1999) and Harrlod and Guarlnick (2010).

Analysis of Data

Biotic index (BI)

BI was used to determine pollution level in the lake. BI is calculated fallowed after Hilsenhoff (1982).

$BI = \frac{\sum ni.ai}{N}$ Where, BI = Biotic index

Ni = number of specimen in each taxon
Ai = tolerance score for each group of taxon
N = number of individuals of insects in a samples

Each family has a pollution tolerance on a scale of 1-10 in which 1 is not tolerance and 10 is extreme tolerance to pollution.

Table 1 Evaluation of water quality using the family-level biotic index (Hilsenhoff, 1988)

Biotic index	Water quality	Degree of organic pollution
0.00-3.50	Excellent	No. apparent organic pollution
3.51-4.50	Very good	Possible slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very poor	Severe organic pollution

Results

Occurrence of aquatic insects

A total of 3196 individuals of aquatic insects were collected at two study sites, in Taungthaman Lake, during July 2019 to June 2020. Of these individuals, a total of 30 species, belonging to 29 genera, 21 families under nine orders were recorded. Among these, 1175 individuals of 25 species, 24 genera from 18 families under eight orders at Site I and 2021 individuals of 28 species, 26 genera from 18 families under seven orders were recorded at Site II. Regarding the seasonal investigation, the highest number of 21 species (246 individuals) in the rainy season, followed by 13 species (274 individuals) in the cold season and the lowest 10 species (655 individual) were recorded at Site I, while in the hot season, 20 species (714 individuals) in the rainy season was observed as the highest occurrence and followed by 19 species (360 individuals) in the cold season and the lowest 15 species (947 individuals) were recorded in the hot season (Fig. 2).

Water quality as biotic index (BI)

There were 11 families of aquatic insects to support the assessment of water quality as biotic index (tolerance level, 1-10). The families were Libellulidae (9), Coenagrionidae (9), Capniidae (1), Gerridae (8), Corisxidae (9), Syrphidae (10), Hydrophilidae (5), Chrysomelidae (5), Dytiscidae (4), Ephydridae (6) and Chironomidae (Red) (8). In this study, the water quality was assessed as fairly poor in both study sites. The highest degradation of water quality (BI) 7.34 in cold season at Site I, followed by 7.31 in hot season at Site II, 7.19 in cold season at Site II, 6.67 in hot season at Site I and 6.47 in rainy season at Site II were recorded (Table 1-3).

Table 1 Recorded biotic index (BI) levels at two study sites

Sites	Season	BI	Water quality	Degree of organic pollution
Site I	Rainy season	6.57	Fairly poor	Significant organic pollution
	Cold season	7.34	Fairly poor	Significant organic pollution
	Hot season	6.67	Fairly poor	Significant organic pollution
Site II	Rainy season	6.47	Fair	Fairly significant organic pollution
	Cold season	7.19	Fairly poor	Significant organic pollution
	Hot season	7.31	Fairly poor	Significant organic pollution

Table 2 The computation of water quality biotic index (BI) at Site I during the study period

No.	Order	Family	Tolerance level (1-10)	Rainy season			Cold season			Hot season		
				No. of species	No. of individuals	Tolerance total value	No. of species	No. of individuals	Tolerance total value	No. of species	No. of individuals	Tolerance total value
1.	Odonata	Libellulidae	9	7	3	27	2	70	630	0	0	0
2.		Coenagrionidae	9	1	2	18	0	0	0	0	0	0
3.	Plecoptera	Capniidae	1	1	3	3	0	0	0	0	0	0
4.	Hemiptera	Gerridae	8	1	15	120	0	0	0	1	80	640
5.		Corixidae	9	1	20	180	1	44	396	1	71	639
6.	Hymenoptera	Syrphidae	10	1	1	10	1	1	10	0	0	0
7.	Coleoptera	Hydrophilidae	5	1	1	5	2	26	130	1	4	20
8.		Chrysomelidae	5	0	0	0	0	0	0	0	0	0
9.		Dytiscidae	4	0	0	0	0	0	0	0	0	0
10.	Diptera	Ephydridae	6	2	119	714	2	98	588	1	393	2358
11.		Chironomidae (Red)	8	0	0	0	1	0	0	0	0	0
						1077			1754			3657
			biotic index (BI) level			6.57		BI	7.34			6.67

Table 3 The computation of water quality biotic index (BI) at Site II during the study period

No.	Order	Family	Tolerance level (1-10)	Rainy season			Cold season			Hot season		
				No. of species	No. of individuals	Tolerance total value	No. of species	No. of individuals	Tolerance total value	No. of species	No. of individuals	Tolerance total value
1.	Odonata	Libellulidae	9	7	16	144	3	68	612	3	4	36
2.		Coenagrionidae	9	1	3	27	0	2	18	0	0	0
3.	Plecoptera	Capniidae	1	1	1	1	0	0	0	0	0	0
4.	Hemiptera	Gerridae	8	0	0	0	1	22	176	1	336	2688
5.		Corixidae	9	0	0	0	1	33	297	0	69	621
6.	Hymenoptera	Syrphidae	10	1	1	10	1	1	10	1	16	256
7.	Coleoptera	Hydrophilidae	5	2	0	0	2	7	35	2	11	55
8.		Chrysomelidae	5	1	1	5	1	2	10	0	0	0
9.		Dytiscidae	4	0	0	0	1	13	52	0	0	0
10.	Diptera	Ephydridae	6	2	102	612	1	122	732	1	360	2160
11.		Chironomidae (Red)	8	1	2	16	1	0	0	0	6	48
						815			1942			5864
			biotic index (BI) level			6.47			7.19			7.31

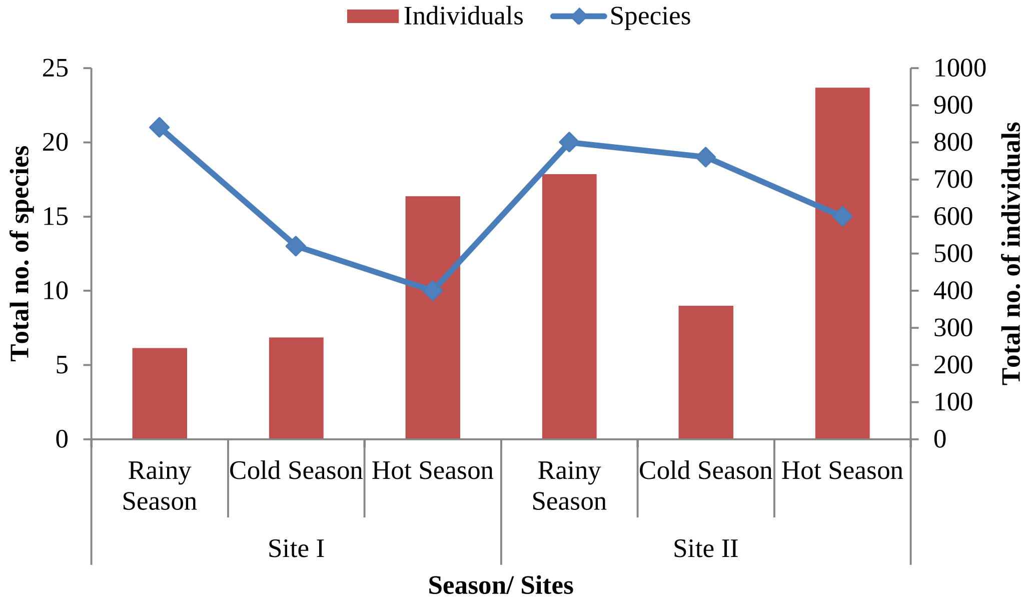

Figure 2 seasonal occurrences of insect species at two study sites

Discussion

In the littoral zone, in which light reaches well, the benthos and macrophytes can grow, and insect diversity is at its maximum. Many differentiated microhabitats are available and physico-chemical factors are less restricting than in the dark, cold, and perhaps anoxic conditions of the deeper waters (Gullan and Cranston, 2010). In the study area, the selected two study sites have various abiotic conditions in each season. The highest precipitation was obviously recorded in rainy season, especially in July to August (4.57 meters) compared to other seasons. The depth in littoral area of study Site II is always lower than that of Site I, which showed the slow water and more varied types of habitat growth. The range of water temperatures, pH and DO were 23.4-34.5°C, 7.1-8, 0.22-7.88 mg/L respectively. The range of turbidity was found from 10.8 to 217 and the highest was found in the hot season and the lowest was found in cold season.

There are 3276 aquatic insects of 30 species, 29 genera, 21 families, under 9 orders were collected from Taungthaman Lake in the study period. The largest occurrence was found in November and the smallest occurrence in March and April at the study Site I. At study Site II, the largest occurrence was found in November and the lowest in July. It is found that November had favorable conditions to survive for aquatic insects while it is in March and April, the water level was at least condition, the water drained flooded water from Ayeyawady River in July.

High abundance of insects was recorded with respect to the quality and size of the water body (Arimoro and Keke, 2016). In the present seasonally study, the highest water volume was found in rainy season and the lowest was in hot season. It clearly indicated the agreement with that stated by Arimoro and Keke (2016). Corixidae and Notonectidae prefer lentic aquatic system as their habitat (Ambrose, 2015, cited by Priawandiputra, *et al.*, 2016). Both Corixidae and Notonectide showed different patterns of abundance (Priawandiputra, *et al.*, 2016). Corixidae is widely distributed in many types of lake such as oligotrophic, mesotrophic and eutrophic lakes (Jastrey, 1981; cited by Priawandiputra *et al.*, 2016). Notonectidae is a predator, which prefer the shallow water (Merrit and Cummins, 1996, Hilsenhoff, 1975). These results were provided by Ambrose (2015) and stated by Priawandiputra *et al.*, (2016). *Notonecta* sp. was found mostly in shallow water. The species, *Orchelimum gladiator* and *Harmonia axyridis* at Site I and species, *Eocapnia nivalis, Spathosterninae prasiniferum* and *Lopidea confluent* at Site II were commonly recorded.

The insect composition and the physcio-chemical parameter values of the water are correlated, where fairly high abundance of insects with respect to the water quality and size of the stream was stated (Adjarho *et al.,* 2013 and Udebuana *et al.,* 2015). Regarding the relationship of aquatic invertebrate and water quality, Tachet *et al.* (2003) also stated that aquatic insects improved the health of a stream, pond, river or a lake and they were good indicators of water quality because they were affected by the physical, chemical, and biological conditions of the water body. The vast occurrence and abundance of Odonata in two sampled stations may be attributed to their diverse feeding pattern and the abundance of aquatic vegetation which have been known to provide good oviposition sites for the member of this order (Braccia *et al.*, 2007). In the present investigation, a total of six orders of aquatic insects were used as assessment tool of lake water quality. The orders include Odonata, Plecoptera, Hemiptera, Hymenoptera, Coleoptera and Diptra. In water quality assessment, organic pollution level ranged from 6.36 of fair to 7.79 of poor quality.

Odonata has relationship with water quality, such as temperature, pH, TDS, DO, total alkalinity and total hardness etc (Azrina *et al.,* 2006) and used as indicators for wetland conservation (Bried *et al.,* 2007). The order Odonata has good indicator species, which are taxonomically well known, relatively easy to identify and having distinct habitat requirements (Krebs, 2001). They are constituted the third most abundant group of insect fauna. Odonata prefer fresh water habitat with rich oxygen so their abundance is seen in winter because there is high dissolved oxygen in freshwater ecosystem in this season (Choudhary and Ahi, 2015). In the present research, their occurrence was recorded from June to November and the most abundance (0.1205) species was *Brachythemis contaminate.* The biotic organic level was 6.36-6.88 (fairly - fairly poor) indicating significant organic pollution. The investigation indicates that Odonata can live in polluted as well as fairly clean water. On the other hand, Odonata shows least diversity and were very sparse in distribution, indicating their preference for freshwater, non- contaminated and well oxygenated habitats (Choudhary and Ahi, 2015). In the present study, the value of dissolved oxygen reached up to 0.22-7.88 mg/L and temperature decreased from 23.4-31.5°C.

Members of Plecoptera are used as biological indicators of water quality, especially for dissolved oxygen levels, thus deteriorating populations of stoneflies mean that poor water quality and it threatens the aquatic insects. The absence of Plecoptera indicates the water quality degradation and physical alteration (Choudhary and Ahi, 2015). In the present result, the plecoptera species, *Eocapnia nivalis* was found in September and October in Site I and August in Site II. It clearly indicated that the water quality level is fair because the flooded water from the Ayeyawady River drained into lake and the level of water is high in two study sites and then reduced while the water level was saved in Site I and reduced in Site II in other months. Thus, the water quality of Taungthaman Lake was fairly clean in August in Site II, and September to October in Site I.

Aquatic Hemipteras stand out as an important group of aquatic insects, which are considered important in environmental reclamation of aquatic habitats and are often used to gauge toxins in an environment (Jansson, 1987; Papacek, 2001; Wollman, 2001). The Hemipterans are associated with macrophytes, their diversity is high during winter as the increasing growth of macrophytes (Choudhary and Ahi, 2015). In the present study, the result was agreed with Choudhary and Ahi (2015); they were more abundance in cold season (winter).

The members of order Hymenoptera inhabit an extremely wide range of habitats and biological environments. Some are parasites, while others are predators, herbivores, gall-formers, fungus feeder, leaf miners or nectar and/ or pollen gatherers (Britton, 2018). In the present study, the Hymenopterans species were found from October to November in cool dry period, and from March to June in dry period. They prefer the flowering time of aquatic vegetation along the edges of lake in the two study sites.

Among coleopteran, the Hydrophilids are predominant in rivers and streams. The members of family Dytiscidae have adapted perfectly well to aquatic life. All adults and larvae are aquatic organisms. The members of family Gyrinidae are found in fresh water ponds, lakes, open flowing streams etc. The members of Haliplidae live among aquatic vegetation along the edges of ponds, lakes, streams and creeks. The abundance occurs in summer because of high rate of decomposition of organic matter due to high temperature which reaches up to 28-30°C. Coleoptera forms the second most abundant group of insect fauna. This group was represented by *Cybister* sp., *Dystiscus* sp., and *Hydrophilus* sp (Choudhary and Ahi, 2015). In the present investigation, dominance of Coleopteran species was found in cold and hot seasons. During this time, most of aquatic plants were found along the edges of habitat and the water temperature ranged from 23.4°C to 34.5°C. The present findings are in conformity with the finding of Choudhary and Ahi (2015).

Presence of Saprophilic species of Diptera indicates that water bodies are grossly polluted with poor water quality characterized by low oxygen and high nutrient concentration, large numbers of pollution tolerant Chronomids which are often indicative of poor water quality. Excellent water quality conditions are often characterized by relatively low densities and high species diversity. The high abundance of *Chironomus* sp. in aquatic body indicates eutrophic nature of water body (Choudhary and Ahi, 2015). In the present study, during hot season, less dissolved oxygen levels of 0.22 mg/L in Site II and 0.35 mg/L in Site I were recorded. The occurrence of Chronomids larvae indicated that the water quality is fairly poor (BI = 7.19- 7.31) when the temperature reached from 23.4°C to 34.4°C.

Conclusion

There were four significant organic pollution levels in this water quality assessment; the water quality of this study lake represented fairly poor at Site I in all seasons and at Site II in the cold season while the good water quality was recorded at Site II in the rainy season and the bad water quality at Site I in the hot season. The present findings indicated that the water quality was dependent on water depth and size of water body, where Site II was inlet water and possessed the larger size of water body in the rainy season and Site I was deeper than that of Site II. Taungthaman Lake is famous for U-Bain Bridge in Mandalay, the second largest city of Myanmar. It is important to maintain the lake in healthy conditions because the lake provides many ecosystem products for the community. The findings of the present research will be helpful for the regular monitoring of the water quality in future in aspect of freshwater ecosystem conservation.

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