Seasonal Changes on Eutrophication Levels of the Taungthaman Lake Water (2018–2019)

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Abstract

Water eutrophication has become a worldwide environmental problem in recent years. The present research was conducted on the Taungthaman Lake near Yadanabon University, Mandalay, Myanmar. Three sampling sites were identified and the lake water quality was analyzed for physicochemical characteristics during the three seasons (rainy, cold and hot) from July 2018 to April 2019. In this research, some physicochemical properties (pH, temperature, electrical conductivity, turbidity, total dissolved solid (TDS), total hardness, total alkalinity, DO, BOD and COD) were investigated using conventional methods to know the water quality. The nutrient levels (orthophosphate, organic phosphate, total phosphate and total nitrogen) were analyzed to assess the eutrophication levels. Moreover the contamination of mineral elements (As, Mn, Fe, Cd, Pb) of lake water samples was also determined by Atomic Absorption Spectrophotometer (AAS) and spectro direct.

Key words : Taungthaman lake water, water quality, nutrient levels

Introduction

Water eutrophication is one of the most challenging environmental problems in the world. Eutrophication comes from Greek words eu meaning "well" and trophe meaning "nourishment" (Xiao–e *et al*, 2008). Eutrophication is the process by which a water body becomes enriched in dissolved nutrients that stimulate the growth of algae. This process may result in oxygen depletion of the water body. When algae die, they decompose and the nutrients contained in that organic matter are converted into inorganic form by microorganisms. This decomposition process which consumes oxygen levels in turn may lead to fish kills and a range of other effects reducing biodiversity (Smith, *et.al.*, 1999).

Taungthaman lake is situated in Amarapura Township of Mandalay Region on the eastern bank of the Ayeyarwady River. It lies between 21°53' N to 21°54' N latitude and 96°03' E to 96°05' E longitude. It is situated about seven miles (11 km) away from the southwest of Mandalay. If

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depth is 8–15 feet (2.4–4.57 meters) with the area of about 1000 acres (404.7 hectares) (Lwin *et al.*, 2018).

Taungthaman lake is a natural flood plain flooded by the inflow of Ayeyarwady River in the rainy season. This natural flood plain is transformed into a permanent lake by the construction of water control gates for fishery. Nowadays, water is not controlled and fishery industry is not done in the lake. The water from the lake flowed down in the winter and hot season (Lwin *et al.*, 2018).

In the winter season, the crops and vegetables are cultivated in the eastern and northern part of the lake. Due to industrial zone development, chemical deposited from the fertilizer used in agricultural farms, sewage disposal and human activity the lake cause pollution. So the eutrophication level of Taungthaman lake water was attempted to determine. The aim of this research is to study the seasonal changes on eutrophication level of Taungthaman lake water.

Materials and Methods

Sample Collection

In the present work, the water samples were collected from three different locations and three feet depth in Taungthaman Lake, Amarapura Township, Mandalay Region on (26.7.2018), (18.12.2018) and (28.4.2019) (Table 1 and Figure 1).

Table 1. Sample Locations and Sampling Dates of Taungthaman Lake Water

Sample locations		Sampling site			Sampling date	Season
		A	B	C		
Latitude	(N)	21°53'17"	21°53'27"	21°53'44"	26.7.2018	Rainy
Longitude	(E)	96°03'43"	96°03'41"	96°03'22"		
Latitude	(N)	21°53'15"	21°53'21"	21°54'30"	18.12.2018	Cold
Longitude	(E)	96°04'29"	96°03'45"	96°04'26"		
Latitude	(N)	21°53'25"	21°53'35"	21°54'43"	28.4.2019	Hot
Longitude	(E)	96°04'08"	96°03'40"	96°04'30"		

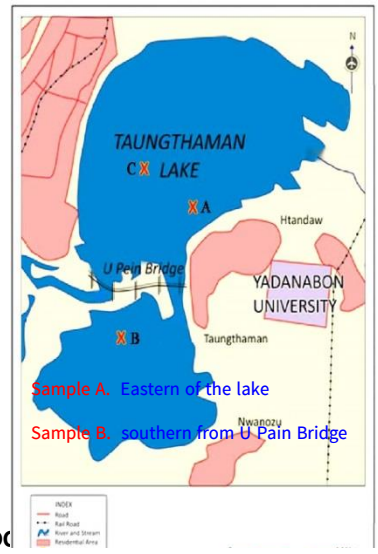

Figure 1. Location map of sampling sites in Taungthaman Lake

Figure 2. Photographs of the water sampling sites on (26.7.2018)

Metho water samples were determined by using pH meter, electrical conductivity meter, turbidity meter and DO meter. Incubation method, permanganate method, titrimetric method, EDTA titrimetric method, evaporation method, Bismuth–phosmolybdate method, alkaline persulphate oxidation digestion

method were used for estimation of BOD, COD, total alkalinity, total hardness, total dissolved solid, orthophosphate and total nitrogen. Total phosphate and toxic mineral elements were investigated by spectro direct and atomic absorption spectrophotometric method.

Results and Discussion

Physicochemical Properties of Lake Water Samples

Variations of pH in Lake Water Samples

At the study area, pH values were found to be 7.7 to 8.4 in rainy season. The pH values were fluctuated from 7.50 to 7.77 in cold season, 7.51 to 8.13 in hot season. The results are presented in Table (2). In the present investigation, pH values of Taungthaman lake water were found to be slightly alkaline in three seasons where the pH varied from 7.5 to 8.4. Among this study, the highest values of pH were observed in sample C collected in three seasons. pH is influenced by acidity of the bottom sediment and biological activities. From the results, the observed values of pH were within the 6.5 to 9.2 of WHO standard.

Variation of Temperature in Lake Water Samples

Temperature is an important factor to induce alga blooming. Alga blooming always occurs at temperature between 23°C and 28°C. During the investigation, the temperature varied from the range of 28°C to 29°C in rainy season, 22.5°C to 24°C in cold season and 31°C to 32°C in hot season. In this investigation, the values of temperature were not exceeded WHO standard (< 35°C). The data are presented in Table (2).

Variation of Electrical Conductivity (EC) in Lake Water Samples

Electrical conductivity is an estimator of the amount of total dissolved salts or ions in water. In present study, the value of EC of lake water is fluctuated from 318 to 902 μS/cm (Table 2). The highest EC was recorded in sample C collected in hot season. It may be due to falling sewage system. In this investigation, all the EC values were not higher than WHO standard (4000 μS/cm).

Variation of Turbidity in Lake Water Samples

Turbidity in natural water is caused by suspended matter such as clay, silt and organic matter. During the study period, turbidity in lake water varied from 33.3 N.T.U to 44.1 N.T.U in rainy season, 76 N.T.U to 105 N.T.U in cold season and 107 N.T.U to 146 N.T.U in hot season. The resultant data are presented in Table (2). The turbidity of water samples collected in hot season is higher than that of the samples collected in other seasons as the lake becomes shallower. It was found that the values of turbidity in lake water were higher than the WHO standards (5 to 20 N.T.U).

Variation of Total Dissolved Solids (TDS) in Lake Water Samples

Total dissolved solids (TDS) are simply the sum of cations and anions concentration expressed in mg/L. A high content of dissolved solid reduces solubility of gases (like O_2) and result into eutrophication of the aquatic ecosystem. In this research, TDS values were found to be in the range of 266 ppm to 289 ppm in the rainy season, 227 ppm to 523 ppm in cold season and 594 ppm

to 649 ppm in hot season. The resultant data are presented in Table (2). High amount of TDS values were found in sample C collected in cold season and all samples collected in hot season due to natural causes, industrial wastewater and inorganic materials. The values of TDS in above lake water were higher than WHO standard.

Table 2. pH, Temperature and Electrical Conductivity, Turbidity, TDS Contents of Taungthaman Lake Water

Sampling site	Parameters					Season
	pH	Temperature (°C)	Conductivity (μS/cm)	Turbidity (N.T.U)	TDS (ppm)	
A	7.7	28	383	33.3	266	rainy
B	7.9	28	374	38.8	289	
C	8.4	29	358	44.1	273	
A	7.77	23	689	92	446	cold
B	7.50	24	318	105	227	
C	7.75	22.5	693	76	523	
A	7.54	31	892	146	647	hot
B	8.13	31	819	107	594	
C	7.51	32	902	109	649	
WHO standard	6.5–9.2	< 35	4000	5–20	≤ 500	

Variation of Total Hardness in Lake Water Samples

The total hardness of water results from divalent cations mainly from calcium and magnesium are expressed as equivalent calcium carbonate. The observed values of total hardness of lake water samples were found to be in the range of 115 ppm to 124 ppm in rainy season, 77 ppm to 167 ppm in cold season and 166 ppm to 218 ppm in hot season.

The data are presented in Table (3). It was found that total hardness of sample C collected in cold season and all samples collected in hot season were higher than those of other samples. On the basic of classification, Taungthaman lake water may be placed under moderately hard to very hard categories. The source of hardness in Taungthaman lake water is mainly due to addition of calcium and magnesium through surface run–off from agricultural and other catchment areas. All these hardness values are within the acceptable range of 500 ppm.

Variation of Total Alkalinity in Lake Water Samples

Total alkalinity is the measure of water's ability to neutralize acids. The observed values of total alkalinity of lake water samples were found to be in the range of 174.41 ppm to 190.10 ppm in rainy season, 135.46 ppm to 331.61 ppm in cold season and 384.40 ppm to 423.17 ppm in hot season. The results are presented in Table (3). In the present investigation the highest value is observed in sample A collected in the hot season which may be due to higher input of nutrient through human activities. Total alkalinity has fallen within the allowable limit of WHO standard (500 ppm).

Oxygen–demanding Substance in Lake Water Samples

Variations of Dissolved Oxygen (DO) in Lake Water Samples

Dissolved oxygen is an important factor determining the water quality and essential for the metabolism of aquatic organisms. DO content of water samples in the studied area were found in the range of 2.96 ppm to 4.35 ppm in the rainy season, 3.69 ppm to 4.08 ppm in cold season and 0.98 ppm to 4.89 ppm in hot season. The data are presented in Table (3). It was found that the value of DO for analyzed sample A collected in hot season was the lowest, which may be due to enrichment of nutrient and algae blooming. Except sample C in rainy season and sample B in cold and hot season, other samples were lower than acceptable ranges (≥ 5) of WHO.

Variations of Biochemical Oxygen Demand (BOD) in Lake Water Samples

BOD is directly affected by the amount of dissolved oxygen in rivers, lakes and streams. The greater the BOD, the more rapidly oxygen is depleted in the lake. In the present study, BOD values of the lake water samples were observed to be in the range of 6.7 ppm to 7.9 ppm in the rainy season, 22.50 ppm to 31.50 ppm in cold season and 38.20 ppm to 59.34 ppm in the hot season. The data are presented in Table (3). The highest values of BOD are observed in sample A and C collected in hot season. It may be due to the over loaded input of organic matter by human activities and the decomposition of organic matter. Generally when BOD levels are high, there is a decline in dissolved oxygen (DO) levels. This is because the demand for oxygen by the bacteria is high. The measured BOD values for all samples exceeded the allowable limit of WHO standard (2 ppm).

Variations of Chemical Oxygen Demand (COD) in Lake Water

COD test indicates the quantity of the oxidation materials present in water. The results are shown in Table (3). From the results, the COD values of lake water samples were found to be in the range of 38.88 ppm to 43.20 ppm in rainy season, 74.0 ppm to121.0 ppm in cold season and 138 ppm to 191 ppm in the hot season in the present study, the highest values of COD were observed in all analyzed samples collected in hot season which showed its high pollution status. The source of COD in Taungthaman lake may be due to input of domestic and industrial drains, human activity, sewage disposal and chemical deposited from the respective fertilizer used in agricultural farms. In all the study area, the COD values were higher than the WHO standard.

Table 3. Total Hardness, Total Alkalinity, DO, BOD and COD Contents of Taungthaman Lake Water

Sampling site	Parameters					Season
	Total Hardness (ppm)	Total Alkalinity (ppm)	DO (ppm)	BOD (ppm)	COD (ppm)	
A	115	174.41	2.96	7.9	43.20	rainy
B	124	190.10	3.21	7	38.88	
C	118	177.23	4.35	6.7	38.88	
A	125	276.73	3.69	31.50	98.5	cold
B	77	135.46	4.08	22.50	121.0	
C	167	331.61	3.80	24.37	74.6	
A	218	423.17	0.98	58.06	191	hot
B	166	384.40	4.89	38.20	138	
C	218	412	1.10	59.34	177	
WHO standard	500	500	≥ 5	2	10	

Nutrient Levels of Lake Water Samples

All living organisms require the nutrients, nitrogen and phosphorus for their growth, metabolism and reproduction. In this research, orthophosphate, organic phosphate, total phosphate and total nitrogen of the lake water samples were studied.

Variations of Orthophosphate, Organic Phosphate and Total Phosphate in Lake Water Samples

In this research, orthophosphate concentration of all samples was determined by bismuth–phosphomolybdate complex method (Mihajlovic, 2007). In the present study, the values of orthophosphate were found to be in the range of 0.14 ppm to 0.25 ppm in the rainy season, 0.15 ppm to 0.39 ppm in the cold season and 0.52 ppm to 0.70 ppm in hot season. The results are presented in Table (4). The highest value of orthophosphate was observed in sample A and C collected in hot season. Orthophosphate is produced by natural processes and is found in sewage. In the present work, the values of organic phosphate were observed to be in the range of 8.75 ppm to 11.79 ppm in the rainy season, 6.15 ppm to 10.59 ppm in cold season and 0.88 ppm to 1.82 ppm in hot season. The resultant data are presented in Table (4). In this investigation, the highest organic phosphate values were found in sample C collected in the rainy season and cold season. Organic phosphate may occur as a result of the break down of organic pesticides which contain phosphate. In the present study, the values of total phosphate were found to be in the range of 9 ppm to 12 ppm in rainy season, 6.3 ppm to 10.9 ppm in cold season, 1.58 ppm to 2.22 ppm in hot season. The resultant data are presented in Table (4). According to the results, the two samples C collected in rainy and cold seasons have the highest total phosphate. The highest phosphate concentration may be due to high rates of decomposition of organic matter and agricultural fields contaminated with phosphate.

Table 4. Orthophosphate, Organic Phosphate and Total Phosphate Contents of Taungthaman Lake Water

Sampling site	Parameters			Sampling date	Season
	Orthophosphate (ppm)	Organic phosphate (ppm)	Total phosphate (ppm)		
A	0.25	8.75	9.00	26.7.2018	rainy
B	0.14	8.86	9.00		
C	0.21	11.79	12.00		
A	0.39	8.91	9.3	18.12.2018	cold
B	0.15	6.15	6.3		
C	0.31	10.59	10.9		
A	0.70	0.88	1.58	28.4.2019	hot
B	0.52	1.82	2.34		
C	0.66	1.56	2.22		

Variation of Total Nitrogen in Lake Water Samples

In the present investigation, the values of total nitrogen in lake water samples collected in the rainy, cold and hot seasons were found to be in the range of 0.242 ppm to 0.491 ppm, 0.650 ppm to 1.135 ppm and 0.920 ppm to 1.812 ppm respectively. The resultant data are shown in Table (5). Among the studies, the highest values of total nitrogen were observed in samples A and C collected in the cold and hot seasons. So it can be said that Taungthaman lake in these regions are eutrophic in nature. The highest values of total nitrogen found in these samples may be due to using fertilizer to increase in the degradation of organic matter.

Evaluation of Nutrient Levels

The nutrient levels of lake water were evaluated based on orthophosphate, total nitrogen and dissolved oxygen (DO). Nutrient enrichment can be divided into three categories: eutrophic level has nitrogen (> 1.0) ppm, orthophosphate (>0.3) ppm and dissolved oxygen (DO) (0 – < 2) ppm, mesotrophic level has nitrogen (> 0.1 – < 1.0) ppm, orthophosphate (> 0.03 – < 0.3) ppm and dissolved oxygen (> 2 – < 5) ppm and oligotrophic level has nitrogen (< 0.1) ppm, orthophosphate (< 0.03) ppm and dissolved oxygen (> 5) ppm (Bricker *et al.*, 1999). Eutrophic levels are characterized by high nutrient concentrations. Mesotrophic levels are characterized by medium nutrient concentrations. Oligotrophic levels are characterized by low nutrient concentrations. According to the criteria value for total nitrogen and orthophosphate, the lake water samples are classified as mesotrophic level in all samples collected in the rainy season and sample B collected in the cold and hot season. Sample A and C, collected in the cold and hot seasons are eutrophic level. Moreover, DO values for all the samples A, B and C in rainy and cold seasons and sample B in hot season were classified as mesotrophic. According to DO values, sample A and C, collected in the hot season is eutrophic level. Based on the three parameters, nitrogen orthophosphate and DO, Taungthaman lake water collected in rainy season is mesotrophic and two studied sites A and C

collected in cold and hot seasons were eutrophic. It can be noted that eutrophication level changes from time to time.

Table 5. Evaluation of Nutrient Levels for Taungthaman Lake Water

Sampling site	Parameters			Sampling period	Season
	Total nitrogen (ppm)	Orthophosphate (ppm)	Dissolved oxygen (ppm)		
A	0.413 (m)	0.25 (m)	2.96 (m)	26.7.2018	rainy
B	0.242 (m)	0.14 (m)	3.21 (m)		
C	0.491 (m)	0.21 (m)	4.35 (m)		
A	1.114 (e)	0.39 (e)	3.69 (m)	18.12.2018	cold
B	0.650 (m)	0.15 (m)	4.08 (m)		
C	1.135 (e)	0.31 (e)	3.80 (m)		
A	1.812 (e)	0.70 (e)	0.98 (e)	28.4.2019	hot
B	0.920 (m)	0.52 (e)	4.89 (m)		
C	1.803 (e)	0.66 (e)	1.10 (e)		

m = mesotrophic e = eutrophic

Variations of Some Elements in Lake Water Samples

In the present study, the values of arsenic, manganese, iron, cadmium and lead in water samples of Taungthaman lake were determined by Atomic Absorption Spectrophotometer and Spectro direct. The resultant data of these some metals are reported in Table (6).

Table 6. Mineral Elements Contents in Water Samples from Different Locations by AAS

Trace metals (ppm)	Sample			WHO standard	Sampling period	Season
	A	B	C			
As	0.03	0.04	0.03	0.05	26.7.2018	rainy
Mn	0.2	0.2	0.3	0.5		
Fe	ND	ND	ND	1.0		
Cd	ND	ND	ND	0.01		
Pb	ND	ND	ND	0.01		
As	0.01	0.005	0.005	0.05	18.12.2018	cold
Mn	< 0.2	0.4	0.31	0.5		
Fe	< 0.1	0.17	< 0.1	1.0		
Cd	0.09	0.173	0.051	0.01		
Pb	< 0.1	< 0.1	0.22	0.01		
As	0.05	0.05	0.015	0.05	28.4.2019	hot
Mn	0.98	1.46	0.44	0.5		
Fe	< 0.1	< 0.1	< 0.1	1.0		
Cd	< 0.1	< 0.1	< 0.1	0.01		
Pb	< 0.1	< 0.1	< 0.1	0.01		

In the present study, the toxic metal arsenic was detected in all the analyzed samples. It was found that concentrations of arsenic were lower in rainy and cold season and within the WHO standard in the hot season. It may be due to drainage of dye stuff effluent. In the study area,

concentrations of manganese were exceeded than WHO standard (0.5 ppm) in the hot season except sample C and lower than WHO standard in other seasons. From the results, iron, cadmium and lead content were not detected in the rainy season. In the present study content of cadmium exceeded the WHO standard in the cold and hot seasons. Lead is a highly toxic metal. In the present study, it was found that lead content of sample C collected in the cold season is higher than WHO standard (0.01 ppm) and other samples were within the WHO standard.

Conclusion

The present study is concerned with water quality around Taungthaman lake, one of the land marks of our region and a natural lake based on physicochemical investigation and evaluation of eutrophication level in three season (July 2018 to April 2019).

The pH values of lake water samples were found to be in the range of 7.5 to 8.4. At the present study, the pH values of lake water samples are slightly alkaline. This range is consistent with the pH 6.5–9.2 WHO standard of aquatic life protection. The values of temperature were found to be in the range of 22.5°C to 32°C. The temperature value was seasonally changed. Temperature over 30°C can cause regression in growth and decays in plant. In the present study, the value of electrical conductivity of Taungthaman lake water fluctuated from 318 μS/cm to 902 μS/cm. The highest value was recorded in sample C collected in hot season due to failing sewage system and industrial wastes. The turbidity of the analyzed samples were found in the range of 33.3 N.T.U to 146 N.T.U. All turbidity values in three seasons were exceeded the permissible level of WHO standard. Among them the highest turbidity value was observed in sample A collected in hot season due to the presence of suspended matter.

The value of total dissolved solids (TDS) were observed in the range of 227 ppm to 649 ppm. The highest value of TDS was observed in hot season at sampling site C. An important criteria of flowing lake water bodies is the amount of dissolved solids. High concentration of dissolved solids can lower water quality by absorbing light.

The total hardness values of lake water samples were found to be in the range of 77 ppm to 166 ppm. The highest value of total hardness was observed in sampling site B collected in the hot season. So this water body can be assumed to be very hard according to National Water Quality Management Strategy, 2000. The values of total alkalinity were found to be in the range of 135.46 ppm to 423.17 ppm. The highest value of total alkalinity was observed in sample A collected in hot season. Total alkalinity of water is primarily caused by the carbonate and bicarbonate ions. The dissolved oxygen (DO) values of the studied area seasonally revealed that all analyzed samples ranged from 0.98 ppm to 4.89 ppm. The DO values for the survival of aquatic life must be at least WHO standard 5.0 ppm. All of the water sample collected in three seasons were lower than the WHO standard. It was found that BOD and COD values were in the range of 6.7 ppm to 59.34 ppm and 38.88 ppm to 191 ppm. BOD and COD are much higher than WHO standard. The lowest DO values and the highest BOD and COD values of sample A and C collected in hot season must be due to the discharges of agricultural and urban waste sources.

According to the concentrations of orthophosphate and total nitrogen in lake water samples, the nutrient levels in the studied area A, B and C (rainy season) and site B collected in cold season were medium (mesotrophic level). In the sampling site A and C collected in cold and hot seasons, nutrient levels are high and it can be regarded as eutrophic level.

The results of water analysis of Taungthaman lake water seasonally indicated that the eutrophication level ranged from medium to high levels. This clearly showed that the Taungthaman lake water of the studied area is polluted and aquatic creatures are under threat due to eutrophication.

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