Physico-chemical and biological water quality analysis of Ambuwaya Lake in Kiangan, Ifugao, Philippines

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Abstract. Freshwater lakes offer a wide range of essential ecosystem services. Physico-chemcical and biological assessment was carried out to determine properties against set standards for Ambuwaya Lake in Kiangan, Ifugao, Philippines. The average pH level of the lake was 7.55±0.39 and the reading was within the set standard of the authorities. The dissolved oxygen and temperature were slightly beyond the set standard but still tolerable by aquatic organisms in the lake. The average Secchi disk visibility reading of 35.56±3.00 cm suggest that the lake was hypereutrophic. Nitrite and total dissolved solids were within the set standards. The lake had high level of ammonia with an average of 2.16±1.18 ppm. Thirteen taxa of plankton were identified. Phylum Myzozoa had the highest abundance due to the dominance of *Peridinium* spp. Diversity index of zooplankton and phytoplankton were considered very low. The evenness of both phytoplankton and zooplankton were categorized as depressed community. The dominance of phytoplankton in the lake was high while the dominance of zooplankton was considered low. The pollution status of Ambuwaya Lake through the Palmer pollution index scored 20 which confirms high organic pollution.
Key Words: bacteria, phytoplankton, plankton, zooplankton.

Introduction. Lake pollution has been a growing environmental concern worldwide due to anthropogenic activities (Rahman et al 2021). The proportion of freshwater on earth’s surface is only 2.5% of which only 1% is accessible for use. In these context, lakes are one of the most important water resources and have been used as a source of water supply for human consumption and in general account for about 0.3% of the total surface water sources (Vasistha & Ganguli 2020). In the Philippines, lakes represent over 70 percent of inland waters. More than half are in Luzon, followed by Mindanao. There are more than 100 recorded freshwater lakes that cover about 200,000 ha (Paller et al 2021). The Ambuwaya Lake is recorded as the 5th largest lake in the Codillera Administrative Region in the Philippines. It is being utilized for irrigation and water for domestic households. According to the Department of Environment and Natural Resources (DENR 2016) of the Republic of the Philippines, it is classified as Class B – Recreational Water Class I (Paller et al 2021).

Given that water is one of the most important life requirements and considering the challenges of its quality management, there is a need to identify and assess the sources of contamination through monitoring and evaluation. Water quality monitoring is given a high priority for the determination of current conditions and long-term trends for effective management (Saalidong et al 2022).

The ecological status of the lake is determined by the plankton composition, which is interpreted as the level of productivity (Senados et al 2021). Changes in the plankton community structure in relation to physicochemical parameters may be a first sign of a deterioration in the water quality (Ochocka & Pasztaleniec 2016).

Material and Method

Description of the study area. This study was conducted at Ambuwaya Lake located at Barangay Ambabag, Kiangan, Ifugao, Philippines (Figure 1), near the coordinates of N16°47'11.42" and E121°5'57.67". The lake has a maximum area of 1.7 ha during the dry season and 2.3 ha during the wet season. It has no visible inflow and outflow; the lake relies on ground water and water rainfall.

Figure 1. Location of Ambuwaya Lake, Kiangan, Ifugao, Philippines (map generated using Google Earth).

Sampling stations. Three sampling stations were considered in this study. The collection of samples in each station were replipcated three times. The exact sampling locations (Table 1) were recorded using the Garmin Ff250 device.

Table 1

Location of the three sampling stations in Ambuwaya Lake

Station	*Location*	*Depth (m)*
Station 1	N16°47.206' E121°05.964'	9.3
Station 2	N16°47.189' E121°05.971'	8.9
Station 3	N16°47.222' E121°05.963'	2.0

Collection of water samples for physico-chemical analysis. Water samples for physico-chemical analysis were collected at the surface and at medium depth. Collected water samples were stored in 500 mL polyethylene (PE) bottles.

Analysis of physico-chemical parameters. Water quality parameters such as pH, dissolved oxygen, ammonia and nitrite were measured on-site using Lamotte Freshwater Aquaculture 02 kit. Temperature was also measureed using a thermometer. The visibility depth of the water was measured using a Secchi disk. The total dissolved solids value was determined using Xaioami TDS meter.

Collection of water samples for plankton analysis. Water samples for plankton analysis were collected in the same sampling stations with a maximum depth of 0.5 m. For the phytoplankton, 10 L of water were collected using a polyethylene recipient and the water was filtered using a plankton net. The net filtered water samples (50 mL) were stored in concave PE bottles and immediately preserved using 0.15 mL Lugols's solution. Water samples for zooplankton analysis was collected using the same procedure and the samples were immediately preserved using 1 mL of 4% formalin.

Identification and quantification of plankton. The preserved water samples were placed in a dark place for three days for plankton settlement. One milliter (1 mL) from 10 mL concentrate was pipetted into a Sedgwick rafter counting chamber. Taxonomic keys of Suthers and Rissik (2009) were used for plankton identification. Biological indices such as abundance, diversity and evenness were computed using the formula adapdted from Boyd and Lichtkoppler (1979); the plankton richness was computed using the formula adapted from Margalef (1958) as cited by Hossain et al (2017). Dominance was calculated using the formula of Simpson (1949) as cited by Rahayu et al (2021). The Palmer pollution index was computed using the proposed plankton pollution indicators by Palmer (1969).

Statistical analysis. Statistical Package for Social Sciences (SPSS) was used to correlate water quality results. One-way Analysis of Variance (ANOVA) was used to compare water parameters from each station. Tukey's Honest Significant Difference (HSD) post hoc test was used to evaluate the significance of differences between pairs of group means.

Results and Discussion

Physico-chemical analysis. The results of thephysico-chemical analysis of Ambuwaya Lake are provided in Table 2. The lake water had a near neutral pH (7.17-8.00; an average of 7.55±0.39) which was still ideal for fish (Lazur 2007).The lake water pH was also within the set standard of the DENR (2016). Dissolved oxygen (DO) concentration was slightly below the optimum level (4.60-5.33 ppm; an average of 4.82±0.39 ppm) but still within the tolerable range for tilapia (*Oreochromis niloticus*) and carp (*Cyprinus carpio*) (PHILMINAQ 2004), species present in the lake. Station 2 had the highest DO of 5.33±0.11 ppm and this was attributed to the existence of aquatic vegetation compared to Stations 1 and 3, where most of the household activities like washing of dishes and clothes were observed. Lake temperature ranged from 30.33-30.83°C with an average of 30.67±0.50°C. The temperature was slightly beyond the set standard by the DENR (2016) (26-30°C) but still tolerable by the fish of the lake. The lake was considered hypereutrophic because the Secchi disk visibility readings were between 33.33-36.67 cm with an average reading of 35.55±3.0 cm. The nitrite level presented in Table 3 ranged from 0.02-0.05 ppm with an average level of 0.04±0.02 ppm; though the DENR (2016) has no set standard for nitrite, the level is still within the acceptable level set by United States – Environmental Protection Agency (US-EPA 2007). The nitrite level of the lake was within the set standard by Pillay (1992) as cited by PHILMINAQ (2004). The total dissolved solids of the lake ranged from 36.67-38.67 ppm with an average of 37.67±1.22 ppm. However, the ammonia concentration of the lake (1.14-2.67 ppm; with an average of 2.16±1.18 ppm) was beyond the level set by DENR (2016). The high level of ammonia may be due to various kitchen waste and decaying plant materials and other discharges from nearby household like detergents since the lake is being used as a washing area. Agricultural run-off from neighboring farms and ricefield may also have contributed to the high ammonia level of the lake.

Table 2

Physico-chemical assessment of the three sampling sites in Ambuwaya Lake

Station	*pH*	*Dissolved Oxygen*	*Temperature (°C)*	*Secchi disk visibility (cm)*	*Nitrite (ppm)*	*Ammonia (ppm)*	*Total Dissolved Solids (ppm)*
Station 1	7.17±0.2^{b}	4.60±0.00^{b}	30.33±0.58^{b}	36.67±2.89^{b}	0.02±0.2^{b}	2.67±0.5^{b}	38.67±0.57^{b}
Station 2	7.50±0.0^{b}	5.33±0.11^{a}	30.83±0.28^{b}	33.33±2.88^{b}	0.05±0.0^{b}	2.67±0.5^{b}	37.67±0.57^{b}
Station 3	8.00±0.0^{a}	4.53±0.11^{b}	30.83±0.57^{b}	36.67±2.87^{b}	0.05±0.0^{b}	3.0±0.00^{b}	36.67±1.52^{b}
Mean	7.55±0.39	4.82±0.39	30.67±0.50	35.56±3.0	0.04±0.02	2.16±1.18	37.67±1.22

Note: Means±SD in columns with the same superscript letter have no significant differences.

Ammonia, nitrite, temperature, total dissolved solids and Secchi disk visibility among stations were not significantly different at p>0.05. However, pH level in Station 3 was significantly higher than Stations 1 and 2. Household run-off like detergents from washing of dishes, clothes and bathing contributes to the rise in pH in Station 3. The station is also a few meters from previous fish cage culture operation. Dissolved oxygen of Stations 1 and 3 was significantly lower than Station 2. Station 2 is an area for collection of freshwater mussels by the locals and tourists of the lake. The presence of aquatic vegatation in the station may have contributed to the higher dissolved oxygen value.

Biological analysis. Results in Table 3 show that 13 taxa of plankton from seven major groups were identified in Ambuwaya Lake. The plankton community was dominated by phylum Chlorophyta. As presented in Table 4, phylum Myzozoa had the highest abundance due to the dominance of *Peridinium* spp. *Peridinium* spp. has been observed in many reservoirs or lakes (Nakamoto 1975; Pollingher & Serruya 1976; Wynne et al 1982; Ikeda et al 1993; Kawabata & Hirano 1995; Fukuju et al 1998; Yamada et al 1998 as cited by Ki et al 2005). The bloom forming *Peridinium* was also observed at Lake Kinneret, Israel (Zohary et al 2012).

Table 3

Listing of phytoplankton and zooplankton identified in Ambuwaya Lake

Phylum/Taxa	*Identified genera*	*Phylum/Taxa*	*Identified genera*
Chlorophyta	*Scenedesmus* *Closterium* *Crucigeniella* *Protococcus*	Arthropoda	*Mesocyclops* *Acartia*
Cyanobacteria	*Merismopedia* *Oscillatoria*		
Euglenozoa	*Phacus* *Euglena*	Cladocera	*Daphnia*
Myzozoa	*Peridinium*		
Ochrophyta	*Navicula*		

Table 4

Abundance (plankton/mL) of phytoplankton phyla in Ambuwaya Lake

Phylum	*Station 1*	*Station 2*	*Station 3*	*Mean*
Chlorophyta	0.27±0.01	0.28±0.10	0.42±0.04	0.32±0.09
Cyanobacteria	0.47±0.08	0.45±0.07	0.36±0.10	0.42±0.09
Euglenozoa	0.17±0.03	0.13±0.03	0.1±0.02	0.13±0.03
Myzozoa	12.85±2.04	17.79±1.48	18.67±0.91	16.44±3.03
Ochrophyta	0.07±0.01	0.06±0.02	0.05±0.01	0.06±0.01

Table 5

Abundance (plankton/mL) of zooplankton phyla in Ambuwaya Lake

Phylum	*Station 1*	*Station 2*	*Station 3*	*Mean*
Cladocera	0.09±0.1	0.04±0.3	0.4±0.01	0.05±0.02
Arthropoda	0.13±0.04	0.1±0.02	0.12±0.00	0.12±0.3

Table 6

Phytoplankton biological indices

Indices	*Station 1*	*Station 2*	*Station 3*	*Mean*
Diversity	0.39	0.29	0.28	0.33
Evenness	0.17	0.13	0.12	0.14
Richness	1.38	1.31	1.31	1.33
Dominance	0.86	0.90	0.91	0.89

Table 7

Zooplankton biological indices

Indices	*Station 1*	*Station 2*	*Station 3*	*Mean*
Diversity	1.07	1.08	1.07	1.07
Evenness	0.97	0.98	0.98	0.98
Richness	0.92	0.82	0.93	0.89
Dominance	0.35	0.34	0.35	0.35

As shown in Table 5, the abundances of zooplankton taxa Cladocera and Arthropoda were 0.05±0.02 and 0.12±0.3 plankton/mL, respectively. The lake had a very low phytoplankton and zooplankton diversity (Boyd & Lichtkoppler 1979) as presented in Tables 6 and 7. The phytoplankton and zooplankon evenness in all stations, according to Boyd and Lichtkoppler (1979), is categorized as a deppressed community. The dominance of phytoplankton in the lake was considered high while the zooplankton was considered low. The pollution status of Ambuwaya Lake through the Palmer pollution index scored 20 which confirms high organic pollution. During the conduct of the study, the authors observed skeletal remains of domesticated animals in the shallow bottom part of the lake which must have contributed to high organic matter.

Conclusions. The analysis of the Ambuwaya Lake in terms of physico-chemical parameters suggests that pH was within the set standards of the DENR (2016). Dissolved oxygen and temperature were slightly above the standards but still tolerable by the living organism in the lake. The visiiblity reading suggest that the lake was hypereutrophic. Nitrite level was within the set standards of US-EPA. However, ammonia level of the lake was beyond the set standard of DENR (2016), this may be due to the observed decaying plants and dead animals from neighboring households. The lake was dominited by *Peridinium* spp. The diversity index of zooplankton and phytoplankton was very low and evenness represents a deppresed community. The lake has high organic pollution according to its Palmer pollution index.

Recommendations. Further studies with additional number of samplings and stations is recommended. Bacteriological assessment of the lake should also be included in the study.

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Conflict of interest. The authors declare that there is no conflict of interest.

References

Boyd C. E., Lichtkoppler F., 1979 Water quality management in pond fish culture. International Centre for Aquaculture experimentation station Auburn University Research Development Series, No 22. 30 pp.

Fukuju S., Takahashi T., Kawayoke T., 1998 Statistical analysis of freshwater red tide in Japanese reservoirs. Water Science and Technology 37:203-210.

Hossain M. R. A., Pramanik M. M. H., Hasan M. M., 2017 Diversity indices of plankton communities in the River Meghna of Bangladesh. International Journal of Fisheries and Aquatic Studies 5(3):330-334.

Ikeda T., Matsumoto T., Kisa H., Ishida Y., Kawai A., 1993 [Analysis of growth limiting factors causative of freshwater red tide by dinoflagellate *Peridinium bipes* f. *occulatum*]. Japanese Journal of Limnology 54:179-189 [In Japanese].

Kawabata Z., Hirano Y., 1995 Growth pattern and cellular nitrogen and phosphorus contents of the dinoflagellate *Peridinium penardii* (Lemm.) Lemm. causing a freshwater red tide in a reservoir. Hydrobiologia 312:115-120.

Ki J.-S., Cho S.-Y., Han M.-S., 2005 Morphological characteristics of *Peridinium bipes* f. *occultatum* (Dinophyceae) isolated from three geographical segregated aquatic systems of Korea. Korean Journal of Limnology, 38(Special issue):1-7.

Lazur A., 2007 Grow-out pond and water quality management. Joint Institute for Food Safety and Applied Nutrition. 18 pp.

Margalef R., 1958 Information theory in ecology. General Systems 3:36-71.

Nakamoto N., 1975 A freshwater red tide on a water reservoir (in Japanese). Jpn. J. Limnol. 36:55-64.

Ochocka A., Pasztaleniec A., 2016 Sensitivity of plankton indices to lake trophic conditions. Environmental Monitoring Assessment 188:622. doi: 10.1007/s10661-016-5634-3.

Paller V., Macandog D., de Chavez E., Paraso M. G., Tsuchiya M. C., Campang J. G., Pleto J. V., Bandal Jr. M. Z., Cabillon Y. C., Elepano A., Macaraig J. R., Mendoza S., 2021 The seven lakes of San Pablo: Assessment and monitoring strategies toward sustainable lake ecosystem. Philippines Science Letters 14(1):158-179.

Pillay T. V. R., 1992 Aquaculture and the environment. Halsted Press, an Imprint of John Wiley & Sons, 605 Third Ave., New York, NY 10158. 189 pp.

Pollingher U., Serruya C., 1976 Phased division of *Peridinium cinctum* f. *westii* (Dinophyceae) and development of the lake Kinneret (Israel) bloom. J. Phycol. 12(2):162-170.

Rahayu A. P., Saad M., Fanni N. A., 2021 Analysis of plankton abundance and status of water quality fish cultivation 'Sawah Tambak' with overtime system in Kalitengah Subdistrict, Lamongan Regency. Advances in Tropical Biodiversity and Environmental Sciences 5(1):17-22.

Rahman K., Barua S., Imran H. M., 2021 Assessment of water quality and apportionment of pollution sources of an urban lake using multivariate statistical analysis. Cleaner Engineering and Technology. Volume 5:100309. https://doi.org/10.1016/j.clet.2021.100309.

Saalidong B. M., Aram S. A., Out S., Lartey P. O., 2022 Examining the dynamics of the relationship between water pH and other water quality parameters in ground and surface water systems. PloS ONE, 17(1):e0262117. https://doi.org/10.1371/journal.pone.0262117.

Senados T., Gomez B., Ratunil V., Dela Pena J., Gamboa G., Borja E., Adlaon M., Odtojan M., 2021 Phytoplankton in Lake Mainit, Philippines. Sustainability and resilience of coastal management. IOP Conference Series: Earth and Environmental Science 799:012028. doi: 10.1088/1755-1315/799/1/012028.

Simpson E. H., 1949 Measurement of diversity. Nature 163:688. http://dx.doi.org/10.1038/163688a0.

Suthers I. M., Rissik D., 2009 Plankton a guide to their ecology and monitoring for water quality. CSIRO Publishing Australia. 273 pp.

Vasistha P., Ganguly R., 2020 Water quality assessment of natural lakes and its importance: an overview. Material today: Proceedings 32(4):544-552.

Wynne D., Patni N. J., Aaroson S., Berman T., 1982 The relationship between nutrient status and chemical composition of *Peridinium cinctum* during the bloom in Lake Kinneret. J. Plankton Res. 4:125-140.
Yamada M., Ono Y., Somiya I., 1998 Accumulation of freshwater red tide in a dam reservoir. Water and Science Technology 37:211-218.
Zohary T., Nishri A., Sukenik A., 2012 Present–absent: a chronicle of the dinoflagellate *Peridinium gatunense* from Lake Kinneret. In: Salmaso N., Naselli-Flores L., Cerasino L., Flaim G., Tolotti M., Padisák J. (eds) Phytoplankton responses to human impacts at different scales. Developments in Hydrobiology, vol 221. Springer, Dordrecht. 161–174 p.
*** Department of Environment and Natural Resources (DENR), 2016 Water quality guidelines and general effluent standard. Administrative order no. 2016-O8. www.water.emb.gov.ph [Last accessed on 10 July 2023].
*** PHILMINAQ, 2004 Water quality criteria and standards for freshwater and marine management. www.aquaculture.asia [Last accessed on 10 July 2023].
*** United States - Environmental Protection Agency (US-EPA), 2007 Consumer factsheet on nitrates/nitrites. https://archive.epa.gov/region5/teach/web/pdf/nitrates_summary.pdf [Last accessed on 10 July 2023].

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