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Water Quality and Fish Fauna in Lake Wood Lake Zamboanga del Sur, Philippines

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Abstract. A pioneering study was done on Lakewood, a freshwater lake located in western Mindanao, Philippines to assess its water quality and fish fauna diversity. The baseline limnology data and environmental conditions of the lake serve as bases to improve local planning, policy formulation and sustainable management of the lake. *In situ* determination of water quality parameters were done on depth-integrated grab samples using portable probe/digital instruments concerning water temperature, TDS, pH, electrical conductivity, chl a, and a depth profile of DO. Identification of the fish species caught was done to document the aquatic faunal diversity present in the lake in association with the existing physicochemical properties of the water. Depth profiles of WT and DO within a 10-m deep water column gave ranges of 26.6 (10-m) - 28.8 ^{0}C (surface); and 5.96 mg.L^{-1}- 7.8 mg.L^{-1}, respectively. The results gave no significant spatial variation. Surface determinations of TDS was 57.44 – 65.11mg.L^{-1}, pH, 7.9-8.8; and EC, 0.07 - 0.09 μS/cm. Chl a that ranged from 0.6 to2.3 mg.L^{-1}; and the BOD, 0.37 – 4.30 ml.L^{-1} both yielded significant spatial differences. Chl a significantly differentiated among stations. Eleven freshwater fish taxa were identified. One commercialized cyprinid, locally known as Porang is endemic to the lake. Four shellfishes taxa belonged to the families of *Unionidae* and *Lymnaeidae.* Recommendations concerning resource conservation and improved management strategies are discussed.

Key Words: lake faunal diversity, Lakewood lake, lake ecosystem, water quality

1. Introduction

This study provides useful information on the water quality and fish species present in Lakewood to a wide audience, ranging from those interested in the fish fauna diversity in the lake, to those needing an overview of its environmental conditions in order to improve planning, management and investment decisions, particularly the tourism industry at the local level. This project is a pioneering attempt undertaken in the large freshwater ecosystem in Lakewood and serves as the first formal documentation of the baseline information in the aquatic biodiversity with emphasis on the fish fauna identification, and water quality properties that influence the existence of the fishes in the lake. These issues were evaluated in the light of the existing biophysical, socioeconomic and cultural scenario of the lake environment.

Water quality is the characteristics of water that define its use and measured in terms of physical, chemical, biological, bacteriological, or radiological characteristics by which the acceptability of water is evaluated, to classify water resources and their beneficial use [1]. The assessment of water quality in this lake and its associations to aquatic species (flora and fauna) will then be elucidated to prioritize and strategize lake conservation efforts as an aid to local policy formulation and management decision support concerning lake water body and its uses. Specifically, this study aims to determine the biological and physico-chemical characteristics of the lake; describe its water quality conditions in terms of DO, pH, TDS,

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BOD, temperature, conductivity, and Chlorophyll a; determine the composition of fish fauna present in the lake, and the influence of selected water quality properties (physico-chemical) on fish diversity of the lake.

The fish fauna data associated with water quality of the lake is also discussed. The data presented is far from definitive, but this strives to be geographically comprehensive, elucidate existing data in a logical manner and to provide a firm foundation for subsequent more detailed assessment and analysis of Lakewood lake and other freshwater ecosystem biodiversity in the region. No attempt has been made to address directly the issue of water availability and quality for human use.

2. Methodology

2.1. Description of the Study Sites

The study was conducted in the Lake of Lakewood, Zamboanga del Sur, Philippines. With geographic coordinates 7^{0}50’36”N and 123^{0}9’47”E at the water’s edge, and elevation of 320 m above sea level (masl). As the Philippines’ 17th largest lake out of 94 and the 7th of 33 lakes in Mindanao, Lake Lakewood has an area of 738 hectares (Fig. 1). The lake is believed to be a collapsed caldera on a volcanic area of generally Pliocene age that consisting mainly of transgressed marine deposits of shale, wacked, and reef limestone. It has bottom springs and is badly dependent on rain because of the evident absence of nearby large water inflow and tributaries. The only outlet of the lake is the Biswangan River which is located on its northeastern shore. The river provides water for irrigation, livestock raising, recreation and other purposes aside from being habitat of aquatic wildlife.

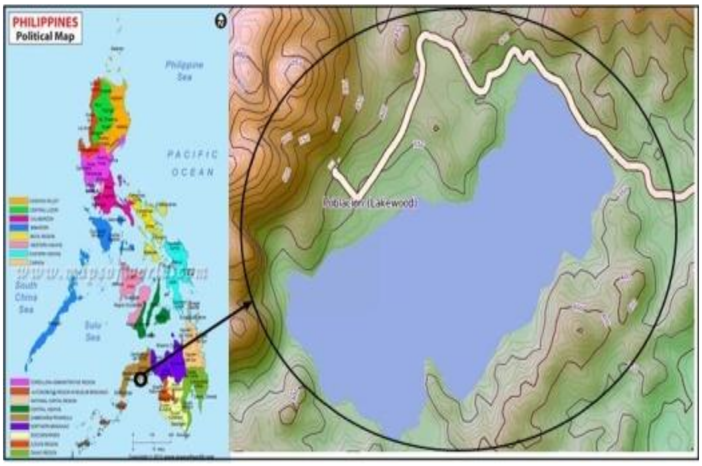

Fig. 1: Location map of the study (Modified from Google Earth Maps, 2012 and generated from GPS Satellite Segment View, January 4, 2012)

2.2. Sampling Scheme

Ritual session of some tribal leaders (Subanen) at a certain portion of the lakeshores was held prior to the conduct of the reconnaissance survey to give due respect to the indigenous culture that manages the lake. Research activities were coordinated with local residents and the Local Government Unit (LGU) of Lakewood.

2.2.1 Sampling Design and Analysis of Water Samples

Stratified and modified integrated-depth grab sampling methods were adopted in the collection of water samples following the procedures in sampling and field test methods discussed in [1], water quality analysis guide [3] and standard for ambient water quality monitoring and analysis[1].

Five (5) sampling stations were strategically located to represent the visually diversified parts of the east-west oriented 738-ha lake. These were established and geo-referenced as follows: Station (07^{0} 51$^{'}$ 193$^{''}$ N and 123’ 11$^{''}$ 010 E) near the outlet of the lake, Station 2 (07^{0} 51$^{'}$ 463$^{''}$ N and 123’ 10$^{''}$ 835$^{''}$ E), near the rice field, Station 3 (07^{0} 50$^{'}$ 576$^{''}$ N and 123’ 09$^{''}$ 995” E) the center, Station 4 (07^{0} 50$^{'}$ 778$^{''}$ N and 123’ 09$^{''}$ 456” E) near the populated area and Station 5 07^{0} 50$^{'}$ 457$^{''}$ N and 123’ 09$^{''}$ 666” E) at the upstream end of the lake Each sampling reach had an approximated area of 2,500 m^{2}. Three (3) sampling sites and collection areas per reach were completely randomized and identified where *in situ* measurements were done. The depths of grab-sampling were 1-2 m, 2-3 m, 3-5 m and 5-10 m. Sampling frequency was twice a month or every other week for a period of seven months.

2.3. Collection of Biological Samples

Fishing activities were undertaken using hook-and-line, drift nets and spear guns were done for three (3) hrs/day for a period of one week. Live fishes were collected in different areas (upstream and downstream zone) of the lake through the aid of the local dwellers. These were subjected to low temperature for storage and species identification. These fishes were individually measured, photographed and taxonomically identified using the field guide to freshwater fish [6,7], [8]and [9]. Taxonomic nomenclature mainly follows the current systematic status presented in FishBase [10] and Fishes of uncertain specific epithet were tagged up to genus level only.

3. Results and Discussion

3.1 Water Quality of Lakewood Lake

The physicochemical properties of the lake are presented in Table 1. As observed, the physicochemical features of the lake water were influenced due to the discharges of domestic waste, sewage, nutrient loads from agricultural activities, and runoff from the populated areas and nearby resort establishment.

There was a significant monthly variation of WT within a range of 26.77 - 28.68^{0}C, $\pm$ 0.52 (P = 0.0008). Highest WT was in the month of March (28.68 ^{0}C), while the lowest in November (26.77 ^{0}C). A similar trend in thermal variation was noted by [11] in his study in Triveni Lake, Amravati District, India. According to him, this range of temperature is favorable to the kinds of fishes he found in that lake some of which were also seen in L. Lakewood, like the families of *Cyprinidae* and *Channidae*. The presently detected temperature regime concurs with the observations of [12] and [10] specifying the temperature tolerance level of freshwater fishes. Temperature is one of the important factors in aquatic environments because it is involved in the regulation of physicochemical processes as well as biological activities [13]. The prevalent water temperature (27^{0}C – 29^{0}C) has strong implications that the needs for growth, survival and reproduction of the identified fish and invertebrate species are generally meet up [14].

Significant variations also occurred among the sampling times (P = 0.0006), the range of station means being from 27.4 to 27.8 ^{0}C, $\pm$ 0.78. The average WT through the 10-m water column was 27. 36 ^{0}C, $\pm$ 0.64. In the overall, no significant thermal variation within the upper 10-m depth of the water column implying that the upper 10-m of the water column was thermally homogeneous in the east west oriented lake.

The significant differences in monthly temperature (P=0.00076), and between sampling times (P=0.0006) were observed. It clearly portrayed the wide range of lake water temperature variations throughout the investigation. No stratification trend of the lake water during the period of study was noticed.

Dissolved oxygen is the concentration of oxygen in the bodies of water and an important regulator of chemical processes and biological activity [15]. The present investigation recorded a monthly mean DO range of 6.12 – 7.52 mgO.L^{-1} . The overall DO mean was 7.18 mg.OL $^{-1}$. The general range in the depth profile for DO was 7.12 – 7.38 mgO.L^{-1}. These DO values are greater than the prescribed standard of 5 mgO.L^{-1} for Class C water resources [16, 17]. They exceed the minimum concentration specified in the water quality criteria [1], implying a good water quality for aquatic organisms, and for other activities such as bathing and fishing.

There were highly significant differences in the DO means (P=0.01) of the sampling stations indicated. Some amount of spatial differentiation among the upstream, center and downstream regions of the lake was observed. However, lowest DO concentration (6.89 mgO.L^{-1}) in the downstream sampling sites where the recreational area nearby is operating was observed. In the current study, the potential contaminants or toxics and nutrient loads from the farms along the edge of the lake, sewage discharges and runoff from the populated and nearby resort establishment areas are believed to be very small in amount only because it did not reduce the amount of DO concentration and to degrade other water quality characteristics of the lake throughout the investigation. The dissolved oxygen is affected by many factors including climate or season, riparian vegetation, suspended solids, amount of nutrients in water and organic wastes [18], to mention a few. Low DO levels may be found in areas where organic material (dead plant and animal matter) is decaying, as bacteria require oxygen to decompose organic waste, thus, depleting the water of oxygen [19]. Regardless these differences, however, the water quality remained acceptable in all three places.

There was no significant differentiation of the arbitrarily determined layers of the 10-m water column. This means that DO in the lake water column within the photic zone is homogeneous. Lake waters were found to have an alkaline pH in all stations and within the upper 10 m. The pattern of pH change indicated slightly increasing levels from January to March. Variation among sampling periods were significant (P=2.49E-10). The possible cause being the periodic accumulation of organic discharges from populated areas of the watershed, tributary inflow and rainfall. This significant pattern of monthly pH variations concurs with the study of [20] who observed a diluting effect of rainfall and the pH elevating effect of domestic wastes [21]. This might also be the reason of high alkalinity values recorded.

Mean TDS fluctuated within the ranges of 59.08 to 63.44 mg. L^{-1}, 60.42 – 60.70 mg. L^{-1} and 56.51 – 63.10 mg. L^{-1}, between sampling periods, stations and depth of the water column, respectively, the differences found were insignificant. These values were within the range set by [1] for waters of good lake water quality. As observed by[22], a TDS range of 45 to 152 mg. L^{-1} in surface water of the Indian Lake at Akola City. The concentration and composition of TDS in natural waters is determined by the geology of the drainage, atmospheric precipitation and the water balance [5, 23].

Table 1: Monthly means of the physicochemical properties of Lakewood. (Nov. 2011–May 2012)

Parameter	Nov	Dec	Jan	Feb	Mar	Apr	May	Std. Error	Std. Dev	P - Value
Temperature, C	26.77	27.95	27.78	27.58	28.68	27.09	27.40	0.24	0.53	0.001
DO, $mg.L^{-1}$	7.47	7.52	7.50	7.17	6.12	7.22	7.52	0.07	0.16	0.057
pH	8.21	8.43	8 .13	8.03	8.70	8.54	8.25	0.04	0.08	2.5E-10
TDS, $mg.L^{-1}$	62.18	63.44	59.08	61.39	59.31	59.31	58.72	1.34	2.99	0.384
Conductivity, (20 mS)	0.13	0.13	0.13	0.13	0.14	0.13	0.13	0.001	0.002	0.005
BOD, $mg.L^{-1}$	__	__	3.70	2.27	2.07	2.20	2.22	0.55	1.22	0.284
Chl a, $mg.L^{-1}$	__	2.32	1.47	2.37	1.86	1.86	0.66	0.26	0.57	0.002

P < 0.05- Ho is rejected and Ha is accepted that at least one of the means are different,
P> 0.05- Ho is accepted that means are almost equal

The monthly mean EC range was 0.130 – 0.136 mS. There were no significant differences in EC among the monitoring stations water depth implying a homogeneous ability of the lake water to conduct electricity. Significant differences occurred among the sampling months (P=0.0048). This might be due to the varying amounts of rainfall entering the lake and the dynamic chemistry of inflowing waters from the watershed.

The monthly mean BOD ranged from 2.07 – 3.70 mg. L^{-1} .Station means and the means at varying depths gave significant variations within a range of 1.60 – 4.01 mg. L^{-1}(P = 0.032). The ranges observed are within the safe limits set by [1] for the protection of water bodies. The amount of BOD in a lake is an indirect measure of the organic strength of wastes in the lake. High concentrations of pollutants and organic matter increase the BOD [11].

The detected concentrations of Chl a across space and time were below monthly concentration of Chl a ranged from 0.66 to 2.37 ug. L^{-1} while in the sampling sites was 1.38 - 2.07 mg. L^{-1} and 1.54 – 1.96 mg. L^{-1} in the water column down to 10 m depth from the water surface. Significant difference in Chl a concentration was noticed between sampling times.

Based on the readings obtained on chla which ranged from 0.66 to 2.37 ug. $L^{-1,}$ Lakewood lake is ultra-oligotrophic according to two classification schemes [24, 25].

3.2. Fish Fauna in Lakewood

The identified fish species inhabiting the lake were classified according to family order (Table 2). The scientific name of each species is specified with its local name used by the local dwellers. There were 11 freshwater fishes collected from the sampling sites representing three (3) species belong to *Cyprinidae* family. These were the *Cyprinus carpio* (Karpa), *Puntius sinotatus* (Pait-pait) and the *Rasbora sp.* (Porang). Two (2) species belonged to Channidae family were *Channa maculata* (Elabo) *and Channa melasoma* (Haloan). The other species belonged to the families of *Anabantidae, Anguillidae, Cichlidae, Clariidae, Hemiramphidae*, *and Osphronemidae,.* They were *Anabas sp*.(Puyu), *Anguilla marmorata* (Kasili), *Oreochromis niloticus* (Tilapia), *Clarias macrocephalus* (Pantat), *Zenarchopterus dispar* (Suloy-suloy), *Trichopodus tricopterus* (Gourami). All of these species inhabited in benthopelagic zone of the lake. Seven (7) of them are native or widespread in the Philippines, three (3) were introduced into the lake [10] and only one is endemic (Porang) to the lake. Four shellfish species were collected from the sampling sites representing three (3) species under the *Lymnaeidae* family. These are the *Pomacea canaliculata* (Kohol), *Lymnae sp.* (Suso) and *Stagnicola sp.* (Gege) while the Taiwan Clam belongs to *Unionidae* family. The two shellfish species were *Sinanodonta woodiana* and *Pomacea canaliculata*. These were native or widespread in the Philippines' lakes. The fish species has been observed also in shallow confined waters in the lake and can survive low oxygen concentration. This is in agreement with the studies of [12] and described in [10].

Table 2: List of fish species collected from Lakewood. (Nov. 2011-May 2012)

Family	Species	Local name	Habitat	Status
Fishes				
Anabantidae	*Anabas sp.*	Puyu	Benthopelagic	Native
Anguillidae	*Anguilla marmorata*	Kasili	Benthopelagic	Native
Channidae	*Channa maculata*	Elabo	Benthopelagic	Native
Channidae	*Channa melasoma*	Haloan	Benthopelagic	Native
Cichlidae	*Oreochromis niloticus*	Tilapia	Benthopelagic	Introduced
Clariidae	*Clarias macrocephalus*	Pantat	Benthopelagic	Native
Cyprinidae	*Rasbora sp.*	Porang	Benthopelagic	Endemic
Cyprinidae	*Puntius sinotatus*	Pait-pait	Benthopelagic	Native
Cyprinidae	*Cyprinus carpio*	Karpa	Benthopelagic	Introduced
Hemiramphidae	*Zenarchopterus dispar*	Suloy-suloy	Benthopelagic	Native
Osphronemidae	*Trichopodus tricopterus*	Gourami	Benthopelagic	Introduced
Shellfishes				
Unionidae	*Sinanodonta woodiana*	Taiwan clam	Benthic	Introduced
Lymnaeidae	*Pomacea canaliculata*	Kohol	Benthic	Introduced
Lymnaeidae	*Lymnaea sp.*	Suso	Benthic	Native
Lymnaeidae	*Stagnicola sp.*	Gege	Benthic	Native

4. Conclusions

The result revealed that there was monthly significant variation in some physicochemical parameters like temperature, pH, conductivity, and Chl a concentration in the lake. Low amount of BOD throughout the entire lake or sampling areas is a manifestation that Lakewood lake water favorably supports the growth and survival of aquatic life present in this body of water. Thus, the current organic discharges into the lake from residential, agricultural and residential areas were unable to influence the present environmental condition of the lake and its physicochemical characteristics in particular. Most of the parameters such as DO and TDS were in the normal range and indicates good quality of lake water. The lake is ultra- oligothropic based on the measured characteristics of the lake.

There were 11 fish species found in the lake and four (4) shellfishes. Sixty four percent of the fishes were native or widespread in the Philippines' lake, 27% were introduced into the lake as classified by [10]Froese and Pauly (2012) and only *Rasbora sp.* (Porang) considered as endemic in the said body of water. These species can tolerate wide ranges of several water parameters as measured and they survived in a given range of current environmental conditions.

The physicochemical properties and fish fauna present in the lake in association with its function as sanctuary for fish and other aquatic life could be the basis in conserving this freshwater body. Control measures or policies in the management of the lake may be instituted by the LGU concern and the residents surrounding the lake to avoid degradation of the water quality particularly in the areas near the agricultural, populated, and recreational zones which are potentially downgrade the physicochemical properties of the water in this lake. Social efforts to prevent environmental damage and unnecessary loss of aquatic valuable and economic resources may be promoted.

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