Bio-physical Monitoring of Lake Buhi, Camarines Sur using Environmental Gradients, Fish and Phytoplankton Diversity, Abundance and Distribution

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Introduction

Lake Buhi, located in Buhi, Camarines Sur, Philippines is famous as the home of the world's smallest commercially available fish known as "sinarapan" (*Mistichthys luzonensis*). Unfortunately, the deterioration of water quality due to intensive aquaculture and agricultural practices causes changes in the composition and distribution of freshwater fauna and flora in Lake Buhi.

Environmental gradients in the lake can influence freshwater fish and phytoplankton distribution. This reality makes fish and phytoplankton assemblages a promising bioindicator in determining the ecological condition of their habitat. Phytoplankton can respond to a wide range of pollutants making them useful in providing early signals of deteriorating water conditions (Lacuna et al., 2012). Meanwhile, fish has longer life span which holds long time record on the quality of its habitat; and it is sensitive to the slightest change in chemical concentration.

Objective. The study aims to determine which physico-chemical parameters and resource use positively affect the abundance, diversity and distribution of fish and phytoplankton in Lake Buhi, Camarines Sur. Nine parameters were tested: water pH, conductivity, dissolved oxygen, phosphate, nitrate, water temperature, turbidity, column depth and light penetration.

Materials and Methods

Phytoplankton, fish and water samples were collected from 8 sampling stations which represent varied zonation and resource uses in Lake Buhi during September and November 2013 (Figure 1).

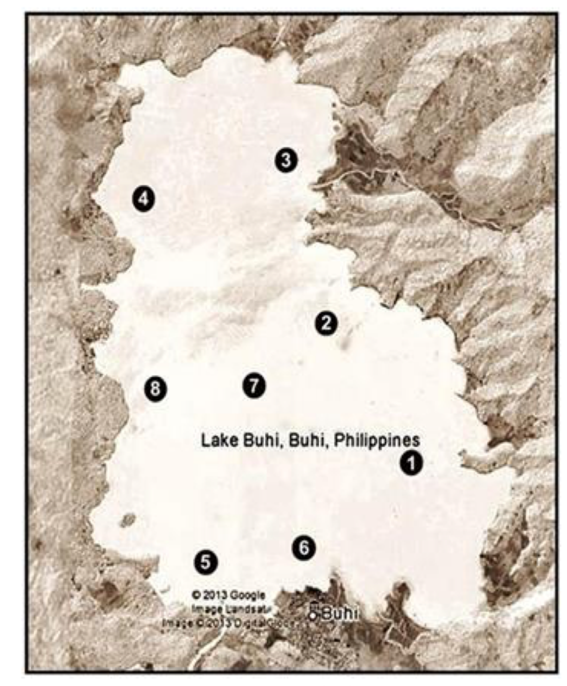

Figure 1. Eight (8) established sampling stations in Lake Buhi, Camarines Sur

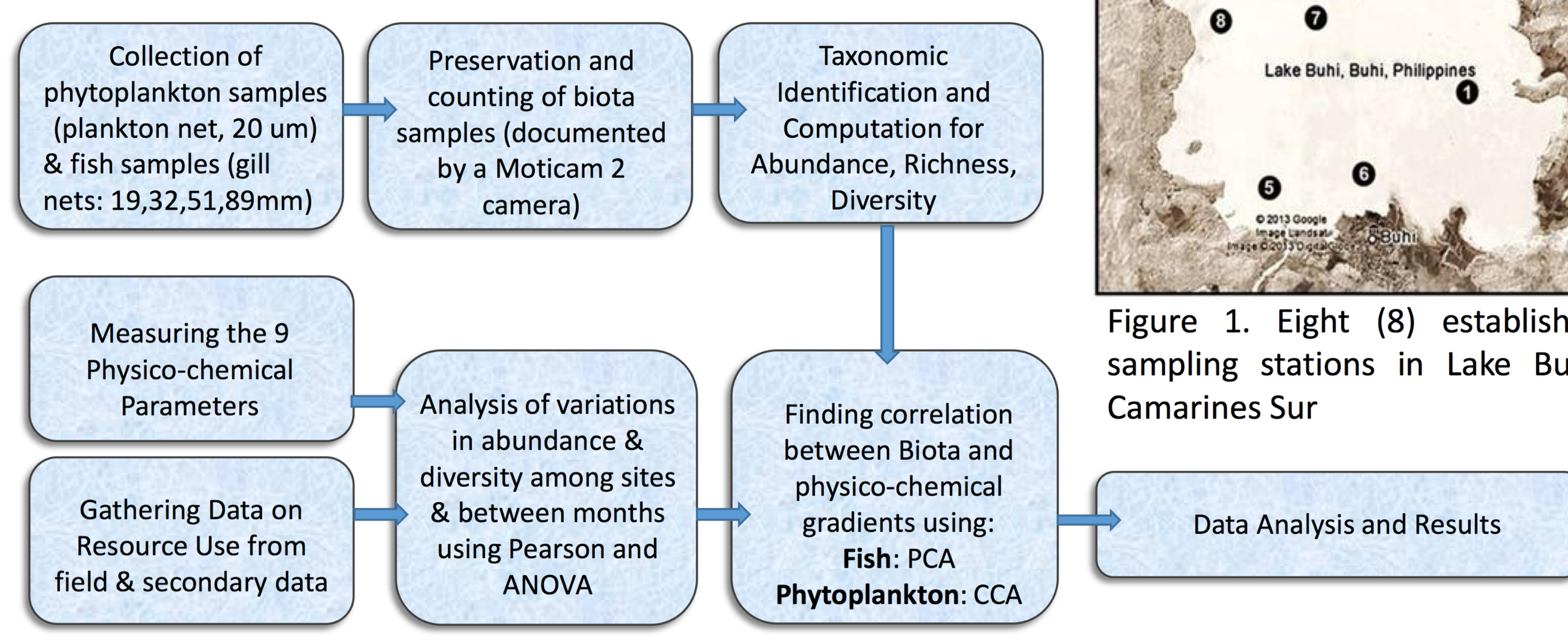

Figure 2. Methodological Framework

Results and Discussion

Phytoplankton and Fish Community Structure

A total of 29 phytoplankton species were found belonging to 5 major phytoplankton groups; while six species of fish were caught in Lake Buhi (Figure 3 and 4). The most abundant plankton species was *Aulacoseira granulata* (28.5%, Figure 5) while the most abundant fish was *Oreochromis sp.* (65 catch, Figure 6). Lake Buhi has a phytoplankton diversity of 2.66 and evenness of 0.46.

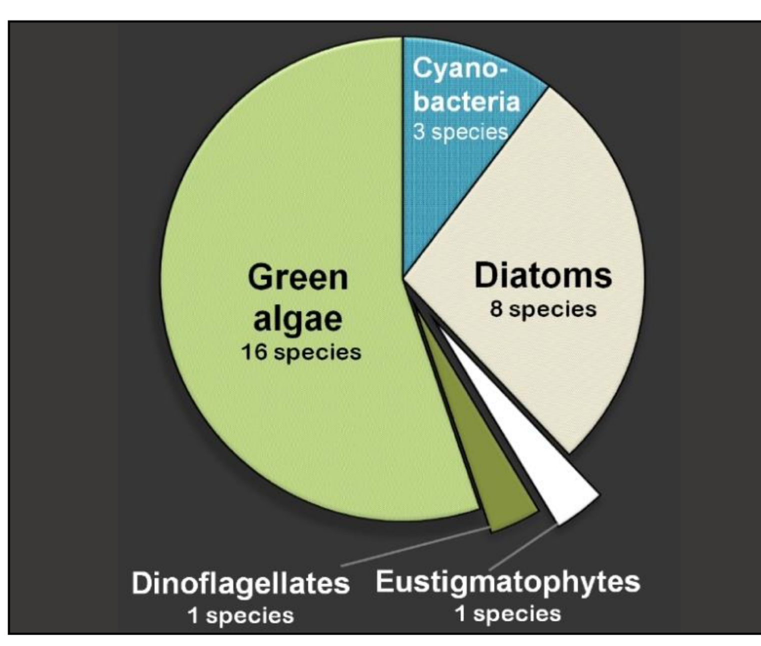

Figure 3. Overall species richness of the different phytoplankton groups collected in Lake Buhi, Camarines Sur, Philippines: green algae (Chlorophyta),diatoms (Heterokonto-phyta), eustigmatophytes, cyanobacteria (Cyanophyta) and dino-flagellates (Dinophyta).

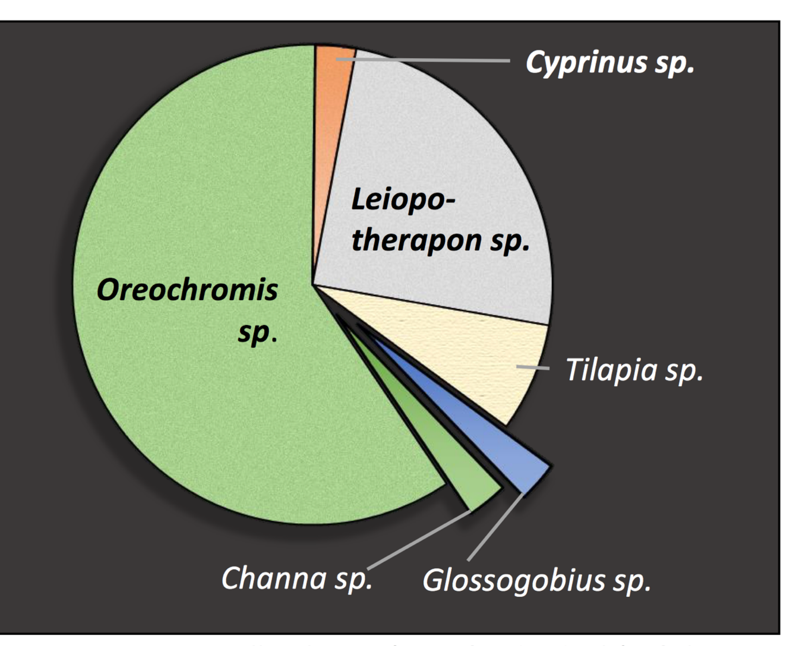

Figure 4. Overall richness (no. of individuals) of the six fish species collected in Lake Buhi, Camarines Sur, Philippines. The fish caught represented 50% of all documented species in the lake.

Physico-chemical Parameters

Nine abiotic factors were measured. Temporal and spatial variations were observed in the physico-chemical parameters in Lake Buhi (Table 1).

Parameter	Station 1	2	3	4	5	6	7	8
SEPTEMBER								
Conductivity (mS/cm)	138	140	140	139	142	143	143	141
Depth (m)	6.6	9.7	8.8	12	9	3.2	13.5	14.7
Dissolved Oxygen (mg/L)	4.2	6.2*	6*	6.4*	7.5*	3.3	6.7*	6.9*
Light penetration (m)	1.5	1.6	1.6	1.4	1.4	1.5	1.5	1.3
Nitrate (mg/L)	12*	9.7	10.4*	7.3	11.1*	5.8	11.7*	9.5
pH	8.4	8.5	8.5	8.9*	8.1	8.1	8.2	8.2
Phosphate (mg/L)	0.11*	0.05	0.14*	0.15*	0.44*	0.53*	0.44*	0.22*
Temperature (°C)	29.1	29.6	29.4	29.2	28.6	28.6	29.1	29
Turbidity (NTU)	6.7	4	4.3	6	6	5.7	5	5
NOVEMBER								
Conductivity (mS/cm)	145	145	148	152	150	149	149	152
Depth (m)	8.3	11.4	10.6	10.6	11.1	8.2	14.9	6.7
Dissolved Oxygen (mg/L)	6.6*	6.7*	7.5*	7.6*	6.7*	6.5*	6.9*	6.6*
Light penetration (m)	1.8	1.7	1.8	1.6	1.8	2.1	1.8	1.6
Nitrate (mg/L)	1.3	2.6	2.8	3	1.4	0.4	1.8	2.7
pH	7.9	7.6	7.7	8.2	8.1	8.1	7.9	8.1
Phosphate (mg/L)	0.85*	0.83*	0.83*	0.89*	0.63*	0.7*	0.78*	0.73*
Temperature (°C)	27.5	27.1	27.3	27.7	27.7	27.6	27.7	28.1
Turbidity (NTU)	6.7	4.7	7	6	6.3	6.3	7.7	4.7

Table 1 Mean values of the physical and chemical parameters in the 8 sampling sites. Asterisk indicates that the value exceeded the standard set for each parameter (DENR 1990, EPA 2012).

Correlation of Environmental Gradients to Biota Abundance & Richness

The fish and phytoplankton abundance and richness were found to be positively affected by some physico-chemical parameters of the lake; and these parameters varied as influenced by resource uses near the specific sampling site (Table 2).

Table 2. Environmental variables with positive correlation to phytoplankton abundance and fish richness in Lake Buhi, Camarines Sur

PHYTOPLANKTON

Month	Physico-chemical parameter	Correlation coefficient	Positively correlated phytoplankton species	Species Description	Stations where positive correlation was was observed	Resource Use
SEP	**Turbidity**	0.68 ns	*Aulacoseira granulata, Aulacoseira muzzanensis, Pediastrum simplex*	tolerant to high levels of nutrients (Maynolov et al. 2009, Bellinger & Sigee 2010)	Station 1 Station 5	- Agriculture, Inlet - Fish pens, Outlet
	Nitrate	0.41 ns	*Aulacoseira granulata, Aulacoseira muzzanensis, Microcystis* sp.	tolerant to high levels of nutrients (Maynolov et al. 2009, Bellinger & Sigee 2010)	Station 1,2,5 & 7	- Agriculture, Inlet - Fish pens, Outlet
			Synedra ulna, Oocystis sp.	tolerant to mild pollution and moderate to heavy organic pollution (Kelly & Telford 2007)	Station 1,2,5 & 7	- Agriculture, Inlet - Fish pens, Outlet
NOV	**Turbidity**	0.32 ns	*Quadrigula* sp.	tolerant from low to moderate nutrients (de Hoyos 2013)	Station 7 Station 3 Station 5	- Fish pens, - Agriculture, Inlet - Fish pens, Outlet
			Scenedesmus arcuatus	tolerant from moderate to high levels of nutrients; common in deep water (Proulx & Pick 1996)		

FISH

Month	Physico-chemical parameter	Correlation coefficient	Positively correlated phytoplankton species	Species Description	Stations where positive correlation was was observed	Resource Use
SEP	**pH**	0.55*	*Glossogobius giuris, Oreochromis niloticus*	Low siltation & well-oxygenated imply chemical and physical degradation; tolerant species in low to medium quality of water	Station 5 Station 7	- Fish pens, outlet - Fish pens, Outlet
	Temperature	0.69 ns	*Glossogobius giuris, Oreochromis niloticus*	Low siltation & well-oxygenated imply chemical & physical degradation	Station 5 Station 7	- Fish pens, outlet - Fish pens, Outlet
	Light	0.76 ns	*Oreochromis niloticus, Leiopotherapon plumbeus* (Fig. 12), *Tilapia zilli* (Fig. 8), *Cyprinus carpio, Glossogobius giuris*	Imply chemical and physical degradation, Low siltation & well-oxygenated	Station 2 Station 3 Station 4	- Fish pens, inlet - Agriculture, Inlet - Fish pens
	Turbidity	-0.60 ns	*Oreochromis niloticus, Leiopotherapon plumbeus, Tilapia zilli, Cyprinus carpio Glossogobius giuris*	Imply chemical and physical degradation, Low siltation & well-oxygenated	Station 2 Station 3 Station 4	- Fish pens, inlet, riparian - Agriculture, Inlet - Fish pens
NOV	**Temperature**	0.69 ns	*Oreochromis niloticus, Tilapia zilli, Channa striata* (Fig. 10)	Imply chemical and physical degradation; tolerant species in low to medium quality of water, Imply presence of insects & nematodes	Station 1 Station 4	- Agriculture, inlet - Fish pens
	Phosphate	-0.51 ns	*Oreochromis niloticus, Tilapia zilli, Channa striata*	Imply chemical and physical degradation; tolerant species in low to medium quality of water, Imply presence of insects & nematodes	Station 1 Station 4	- Agriculture, inlet - Fish pens

Conclusion

Phytoplankton abundance was positively affected by turbidity and nitrate while fish richness was positively influenced by turbidity, pH, temperature, phosphate, DO and light penetration. Both aquaculture and agriculture contributed to the variations in environmental gradients. **Factors such as low species diversity and richness of fish; proliferation of pollution-tolerant phytoplankton; and high level of nutrients and turbidity reflected that the current biological integrity of Lake Buhi is very low.**

Fig. 5. *Aulacoseira granulata*

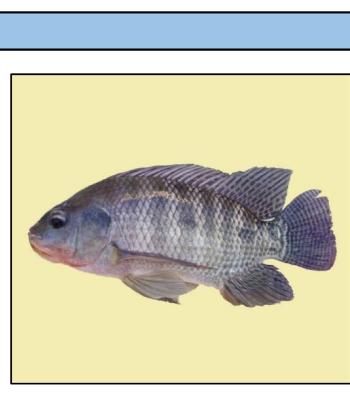

Fig. 6. *Oreochromis niloticus*

Fig. 7. *Coelastrum* sp.

Fig. 8. *Tilapia zilli*

Fig. 9. *Pediastrum simplex*

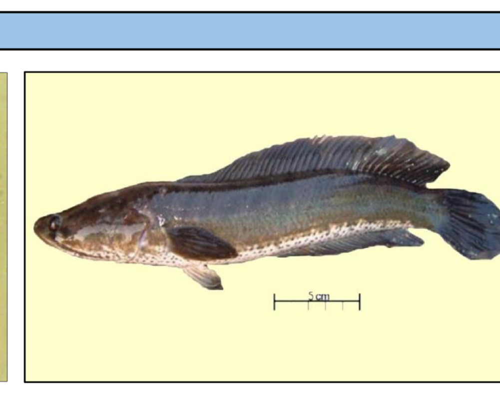

Fig. 10. *Channa striata*

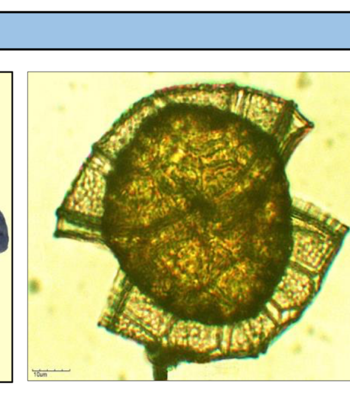

Fig. 11. *Peridinium* sp.

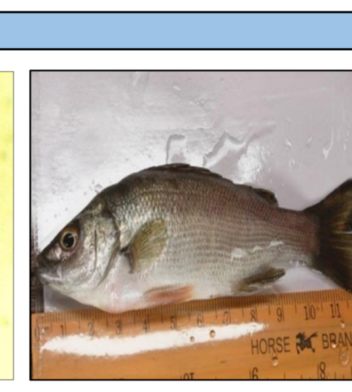

Fig. 12. *Leiopotherapon plumbeus*

Fig. 13. *Staurastrum gracili*

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Acknowledgments

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