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Physico-Chemical Properties of the Fish Pond Water in CMU, Bukidnon, Philippines

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ABSTRACT

Good water quality is a key component of sustainable aquaculture production. The present study reports the water physico-chemical properties of selected fish ponds in Central Mindanao University, Bukidnon, Philippines. The values of the parameters ranged from pH 8.36-8.64, 26.73-27.61 °C temperature, 203-211 µS/cm electrical conductivity, 98-128 NTU turbidity, 13.04-13.78 mg/L dissolved oxygen, 0.095-0.104 g/L total dissolved solids, 73.2-81.9 mg CaCO3/L total alkalinity, 91.0-101.9 mg CaCO3/L total hardness, 11.18-27.86 mg/L sulfate, 0.44-1.08 mg/L chloride, 24.61-50.52 mg/L phosphate, <0.001 mg/L cadmium, <0.01 mg/L lead, and <0.001 mg/L mercury. These findings conformed to the water quality guidelines for aquaculture production except for turbidity and phosphate content. Chloride concentrations were also remarkably low. It is recommended to conduct regular monitoring of the physico-chemical parameters of the pond water, and undertake corrective measures to reduce turbidity and phosphate to an acceptable level and increase the chloride to a level specifically suitable for catfish production.

Keywords: fish pond, physico-chemical parameters, CMU

INTRODUCTION

The global aquaculture industry has grown in the past decades, with food fish supply increasing at an average annual rate of 3.2 % (Food and Agriculture Organization of the United Nations [FAO], 2014). According to Subasinghe (2015), fish production would double by 2030 to meet the world's growing demand and needs. The aquafarming in the Philippines includes catfish and tilapia production. Statistics show that from 2011 to 2015, there was a volume production increase of 16.2 % for catfish, from 3,100 to 3,600 MT, and 1.48 % for tilapia, from 257,400 to 261,200 MT (Philippine Statistics Authority, 2016). The promising productivity of catfish and tilapia farming has prompted Central Mindanao University (CMU), an agricultural university in Bukidnon, Philippines, to venture into aquaculture. In less than a year of active operation, the tilapia-catfish project has proven to be a potential big income earner.

An indispensable consideration for optimum and sustainable production of catfish and tilapia is good water quality. In recent years, however, inland waters have been altered ecologically partly due to anthropogenic activities. The continued degradation of water resources resulting from chemical contaminations of water bodies poses a threat to freshwater aquaculture (Patil et al., 2012; Njoku et al., 2015). Poor water quality can result in poor fish quality, low profit, and potential human health risks (South Africa Department of Water Affairs and Forestry [DWAF], 1996).

The CMU tilapia-catfish fishpond area is located along the National Highway and adjacent to the PhilRice and University rice fields. The water sources of the fishpond are the National Irrigation Administration Canal and the Kibalagon Creek, which channel agricultural runoffs and wastewater discharge from nearby households and market stalls. These environs, as well as water supply, pose potential sources of contamination of the pond water. Thus, this study was conducted to determine and assess the physico-chemical properties of the fish pond water in Central Mindanao University, Bukidnon, Philippines.

METHODOLOGY

Duration and Location of the Study

The study was conducted from February to June 2017. Sampling was done at the tilapia-catfish fish pond of Central Mindanao University, Bukidnon, Philippines, with geographical coordinates of 7°50′57.8″ North latitude and 125°02′54.8″ East longitude. In the study, only the three big fish ponds with areas ranging from ~1,800-2,500 square meters and water depth of one meter were selected as sampling sites. Specifically, Pond 1 is adjacent to the University rice fields with the aqua-duckery facility on one side of the pond (*Figure 1*). Pond 2 is along the national highway (*Figure 2*). Pond 3 is near the PhilRice at CMU facility and its rice fields, and with the aqua-duckery facility on one side of the pond (*Figure 3*).

Collection of Samples

Water samples from the three selected fish ponds were collected on the morning of March 14, 2017. Sampling was done in a zigzag manner giving five subsites: the center and the four corners (2 meters away from the edge of the pond). In each subsite, a water sample was collected approximately 0.5 m below the pond water surface. The water samples were stored in an ice-cold styrofoam container.

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Figure 1. Pond 1 has its one side adjacent to the rice fields and has an aqua-duckery facility

Figure 3. Pond 3 is adjacent to the PhilRice at CMU facility and its rice fields

Figure 2. Pond 2 is along the national highway

Physico-chemical Analysis

Table 1 shows the list of methods used to analyze the water samples from the different ponds for physico-chemical characteristics. The pH, temperature, electrical conductivity, turbidity, dissolved oxygen, and total dissolved solids were determined *in situ*. Analysis of the other parameters was done at the Chemistry Laboratory, CMU for alkalinity and hardness, at the Soil and Plant Analysis Laboratory (SPAL), CMU for phosphates, and at the F.A.S.T. Laboratories at Cagayan de Oro City for sulfates and chlorides. Water samples for metal determination were digested according to the APHA-AWWA 3030E method using nitric acid (American Public Health Association [APHA],1998). The digested water samples and reagent blank were submitted for analysis to the F.A.S.T. Laboratories, an ISO/IEC 17025:2005 accredited testing laboratory for physico-chemical analysis of water samples.

Table 1

Methods of Water Analysis

Parameter	Method of Analysis
pH	Horiba U-52G kit
Temperature, °C	Horiba U-52G kit
Turbidity, NTU	Horiba U-52G kit
Total dissolved solids, g/L	Horiba U-52G kit
Electrical conductivity, µS/cm	Horiba U-52G kit
Dissolved oxygen, mg/L	Horiba U-52G kit
Alkalinity, mg $CaCO_3$/L	Titration with sulfuric acid using phenolphthalein (phenolphthalein alkalinity) and methyl orange (total alkalinity) indicators
Total Hardness, mg $CaCO_3$/L	EDTA titrating using Eriochrome Black T indicator
Chloride, mg/L	Argentometric titration using potassium chromate indicator
Sulfate, mg/L	Turbidimetry
Phosphate, mg/L	Colorimetry
Metals (Cd and Pb), mg/L	Flame Atomic Absorption Spectrometry
Mercury, mg/L	Cold Vapor Atomic Absorption Spectrometry

Statistical Analysis

The data were subjected to one-way analysis of variance. Significant differences among means were evaluated using Tukey's Test at 5 % probability level.

RESULTS AND DISCUSSION

Good water quality is an indispensable feature of a viable aquaculture operation. Poor water quality can result in low productivity and potential human health risk. Table 2 and 3 summarize the results of the physico-chemical analysis of the water samples from the selected fish ponds of Central Mindanao University, Bukidnon, Philippines. Except for dissolved oxygen and heavy metals (Cd, Pb, and Hg), significant differences ($p < 0.05$) in the water physico-chemical parameters were observed among the fish ponds studied. The discrepancies in the results might be due to the differences in the collection time, the existence of the aqua-duckery facility, and the environs of the ponds. Nonetheless, the results of the physico-chemical analysis of the water samples from the fish ponds studied were relatively similar to conformance to the water quality guidelines for aquaculture production.

pH

The pH of water refers to its hydrogen ion (H+) activity. It serves as an index of the intensity of the acidic or basic character of water. In the study, the pH values of the pond water were found to vary from 8.36 to 8.64. These values indicate slight alkalinity of the pond water which can be attributed to the presence of bicarbonates. It has been known that pH is interdependent with other water quality parameters, such as alkalinity and hardness. For most freshwater species, the desirable pH range is between 6.5 and 9.0 (DWAF, 1996; Stone et al., 2013; Department of Environment and Natural Resources [DENR], 2016). The present results are within this required range for fish production and similar to those reported by Njoku et al. (2015) and Sayeswara et al. (2010). In contrast, Sandoval et al. (2017) have reported relatively higher pH values ranging from 8.70 to 9.57 for fishpond water in Pampanga, Philippines.

Temperature

Temperature is one of the most crucial physical variables for the aquatic ecosystem as it affects the metabolism, physiology and reproduction of fish as well as the physico-chemical parameters of water (Snyder, 2018). In the study, the temperature of the pond water ranged from 26.73 to 27.61°C. The temperature readings of the pond water samples are within the optimum water temperature range of 25-31°C (DENR, 2016) for the growth and reproduction of freshwater fish. The present results are relatively lower than those reported by Sandoval et al. (2017).

Electrical conductivity

Electrical conductivity is an index of mineralization and salinity as it estimates the total ionic content of water. The electrical conductivity values of the pond water ranged between 203 and 211 µS/cm. The acceptable limit for electrical conductivity in pond water fishery is 60-2,000 µS/cm (Stone et al., 2013). Thus, the parameter condition is favorable for aquaculture production.

Turbidity

Turbidity is the reduction of transparency due to the presence of suspended or dissolved particles in water that scatter light making the water appear cloudy or murky (Minnesota Pollution Control Agency [MPCA], 2008). The turbidity of the pond water samples ranged from 98 to128 NTU. The present findings exceed the maximum permissible turbidity of 25 NTU (MPCA, 2008) and 80 NTU (Queensland Department of Environment and Heritage Protection, 2009) for water fishery. High turbidity can be attributed to particulate matters including suspended soil particles, planktonic organisms, fish wastes, uneaten fish

Table 2

Mean pH, temperature, electrical conductivity, turbidity, dissolved oxygen, total dissolved solids, total alkalinity, and total and calcium hardness of the fish pond water of Central Mindanao University, Bukidnon, Philippines compared with regulatory standards

Parameter	Pond 1	Pond 2	Pond 3	Regulatory Standard
pH	8.36 ± 0.21^{b}	8.63 ± 0.18^{a}	8.64 ± 0.08^{a}	6.5-9.0 [1,2,3]
Temperature, °C	27.30 ± 0.08^{b}	27.61 ± 0.16^{a}	26.73 ± 0.09^{c}	25-31 [1]
Electrical Conductivity, µS/cm	$209 \pm 11^{a,b}$	211 ± 4^{a}	203 ± 7^{b}	60-2,000 [3]
Turbidity, NTU	128 ± 48^{a}	$116 \pm 17^{a,b}$	98 ± 22^{b}	≤ 25[4]
Dissolved Oxygen, mg/L	13.17 ± 0.84^{a}	13.04 ± 0.78^{a}	13.78 ± 1.03^{a}	≥ 5.0[1,5]
Total Dissolved Solids, g/L	0.104 ± 0.00^{a}	0.095 ± 0.00^{b}	0.104 ± 0.00^{a}	< 16
Total alkalinity, mg CaCO3/L	81.9 ± 5.2^{a}	73.2 ± 8.7^{b}	$78.2 \pm 4.5^{a,b}$	50-150[3]
Total hardness, mg CaCO3/L	91.0 ± 6.9^{b}	$94.0 \pm 9.5^{a,b}$	101.9 ± 10.4^{a}	50-150[3]

Values are means ± standard deviation for fifteen replicates.
[a,b,c] Means with the same letter superscript within a row are not significantly different at 0.05 level of significance using Tukey's Test.
[1]DENR (2016); 2DWAF (1996); [3] Stone et al. (2013); [4]MPCA (2013); 5ANZECC & ARMCA (2000); [6]Scannell & Jacob (2001)

feeds, and other humic substances produced through the decomposition of organic matter (Baotong et al., 1983; Swann, 1997; MPCA, 2008). Furthermore, mechanical activities associated with the bottom feeding fish, such as the catfish, stir up the bottom mud (Swann, 1997). Although catfish prefers turbid waters, excessive turbidity can irritate fish and precipitate disease (Buttner, 1993). High turbidity can affect the feeding ability, growth, and reproduction of fish (Bash & Berman, 2001). According to Bhatnagar and Devi (2013), muddy water is not good for fish culture because soil particles clog gills, which can result in death. Moreover, high turbidity lowers the water dissolved oxygen level by restricting light penetration resulting in the reduction of photosynthetic activity and absorbing heat from sunlight, thus, increasing the water temperature (PHILMINAQ, 2008).

Dissolved oxygen

The level of dissolved oxygen (DO) in water is commonly used as an indicator of water quality. Maintaining adequate concentrations of DO is vitally important for supporting fish, invertebrates, and other aquatic life. In the study, the dissolved oxygen level of the pond water ranged from 13.04 to 13.78 mg/L. The results conform to the water quality guideline of > 5.0 mg/L dissolved oxygen for fish production (Australian and New Zealand Environment and Conservation Council [ANZECC] & Agriculture and Resource Management Council of Australia [ARMCA], 2000; Ekubo & Abowei, 2011; Department of Environment and Natural Resources [DENR], 2016). The present findings are relatively higher than those reported for fish pond water in Pampanga, Philippines, with DO ranging from 5.20-7.57 mg/L (Sandoval et al., 2017). According to Wellborn (1988), less than 4 mg/L dissolved oxygen in water retards the growth of catfish, and one mg/L oxygen concentration is fatal. At zero salinity, one mmHg atmospheric pressure, and 26.73-27.61 °C, the saturation level of dissolved oxygen in water is around 8 mg/L (Maine Volunteer Lake Monitoring Program, 2014). In the tropical fish pond supplied with high nutrients and with the temperature around 30°C or above, the oxygen concentration would go high, having a daily maximum in the oxygen of 2-3 times the saturation level owing to the high oxygen production by the phytoplankton (FAO, n.d.).

Total Dissolved Solids

Total Dissolved Solids (TDS) include the mineral and dissolved organic matter. The TDS in the pond water samples ranged from 0.095 to 0.104 g/L, which is below the maximum allowable level of < 1 g/L TDS in water (Scannell & Jacobs, 2001). These findings suggest that the pond water is suitable for aquaculture farming concerning to total dissolved solids.

Alkalinity

Alkalinity is a chemical measurement of the buffering capacity of water or its ability to neutralize acids, thus, protecting the aquatic organisms from major fluctuations in pH (Swann, 1997). In the study, all the pond water samples recorded zero phenolphthalein alkalinity, while the total alkalinity ranged from 73.2 to 81.9 mg CaCO3/L. These findings indicate a bicarbonate type of alkalinity (India Central Pollution Control Board [ICPCB], 2011), which supports the slightly basic character of the pond water samples having pH values of 8.36-8.64. It has been known that bicarbonates represent the major form of alkalinity in natural water. Bicarbonate alkalinity occurs as a result of the uptake of CO2 and the weathering of carbonate minerals in rocks and soil (White, 2011). The present results fall within the water quality criterion for good pond productivity and protection of aquatic species (DWAF, 1996; Swan, 1997; ANZECC & ARMCA, 2000; Santhosh & Singh, 2007; Stone et al., 2013).

Hardness

Hardness is a measure of alkaline earth elements such as calcium and magnesium in pond water. The total hardness of the pond water samples ranged from 91.0-101.9 mg CaCO3/L, indicative of moderately hard water (ICPCB, 2011). The results conform to the water quality standards for fish culture (DWAF, 1996; ANZECC & ARMCA, 2000; Santhosh & Singh, 2007; Stone et al., 2013). In the study, the obtained total hardness is greater than the total

Table 3

Mean sulfate, chlorides, phosphate, cadmium, lead, and mercury of the fish pond water of Central Mindanao University, Bukidnon, Philippines compared with the Philippine Department of Environment and Natural Resources (DENR, 2016) water quality guidelines for fishery freshwater Class C

Parameter	Pond			DENR Standard
	1	2	3	
Sulfate, mg/L	$14.62\pm1.18_{b}$	$27.86\pm5.23_{a}$	$11.18\pm2.83_{b}$	< 275
Chloride, mg/L	$1.08\pm0.24_{a}$	$0.44\pm0.14_{b}$	$0.52\pm0.11_{b}$	< 350
Phosphate, mg/L	$27.53\pm2.34_{b}$	$50.52\pm2.60_{a}$	$24.61\pm1.62_{b}$	< 0.5
Cadmium, mg/L	<0.001	<0.001	<0.001	<0.005
Lead, mg/L	<0.01	<0.01	<0.01	<0.05
Mercury, mg/L	<0.001	<0.001	<0.001	<0.002

Values are means±standard deviation for five replicates.
a,b,c Means with the same letter superscript within a row are not significantly different at 0.05 level of significance using Tukey's Test.

alkalinity; both expressed as $CaCO_3$. Accordingly, the water hardness is both carbonate (temporary) and non-carbonate (permanent) in nature (ICPCB, 2011). The amount of hardness equivalent to alkalinity constitutes the carbonate hardness, while the amount of hardness over total alkalinity gives the non-carbonate hardness. The present findings suggest that the pond water hardness is mainly temporary in nature and caused by the bicarbonates. Contributory to non-carbonate hardness might be the association of the hardness-causing cation with sulfate, chloride, or nitrate (ICPCB, 2011).

Sulfate

Sulfate is a naturally occurring anion in freshwater. The concentrations of sulfate in the pond water ranged from 11.18 to 27.86 mg/L. These findings are below the maximum permissible limit of 275 mg/L for sulfate in aquaculture (DENR, 2016). Thus, the parameter condition is suitable for fish production.

Chloride

Chloride is a common component of most waters and is beneficial to fish in maintaining their osmotic balance (Stone et al., 2013). The chloride concentrations in the pond water ranged from 0.44 to 1.08 mg/L. Although the present results are below the maximum permissible chloride level of 350 mg/L for freshwater fish culture (DENR, 2016), the remarkably low chloride content is worth noting as it poses a concern, especially for catfish production. According to Stone et al. (2013), the desirable minimum level of chloride for commercial catfish ponds is 100 mg/L because these species are susceptible to "brown blood" disease. Chloride concentrations can easily be increased by adding "mixing" salt to the water.

Phosphate

Inorganic phosphorus is soluble in water and readily utilized by aquatic primary producers. The phosphorus in water usually occurs in the form of phosphate (Stone et al., 2013). The phosphate in the pond water samples ranged from 24.61 to 50.52 mg/L. These values exceed the maximum permissible limit of 0.5 mg/L for freshwater aquaculture (DENR, 2016), although ANZECC and ARMCA (2000) has imposed a stricter water quality guideline of <0.1 mg/L phosphate for the protection of aquaculture species. It is worth noting that the main water sources of the ponds are the Kibalagon Creek and the irrigation canal. Phosphate might have been introduced into the pond through agricultural runoffs carrying phosphorus from fertilizers and insecticides, commercial and domestic waste and sewage from the use of detergents, as well as the fish feeds and duck manure droppings (Baotong et al., 1983; Stone et al., 2013; Njoku et al., 2015). According to MPCA (2008), phosphorus from various sources can cause algae growth resulting in increased turbidities. Excessive phytoplankton turbidity can lead to depletion of dissolved oxygen levels due to increased rates of respiration during the night (Swann, 1997).

Heavy Metals

The heavy metals such as cadmium, lead and mercury in all the pond water samples were non-detectable, i.e., below the method detection limit of 0.001 mg/L for cadmium, 0.01 mg/L for lead, and 0.001 mg/L for mercury. The results conform to the quality standard of <0.005 mg/L cadmium, <0.05 mg/L lead, and <0.002 mg/L mercury for fishery freshwater (DENR, 2016).

CONCLUSIONS

The present study provides valuable data on the physico-chemical properties of the fish pond water of Central Mindanao University, Bukidnon, Philippines. Parameters such as pH, temperature, electrical conductivity, dissolved oxygen, total dissolved solids, total alkalinity, total hardness, sulfate, chloride, cadmium, lead, and mercury were within the acceptable levels to sustain aquaculture production. However, turbidity and phosphate content of the pond water exceeded quality guidelines for aquaculture production. Although the chloride concentration did not exceed the maximum permissible chloride level for freshwater fish culture but the remarkably low chloride content is a concern, especially for catfish production. Except for dissolved oxygen, cadmium, lead, and mercury, there are significant differences in the physico-chemical properties among the fish ponds studied.

RECOMMENDATIONS

It is recommended to undertake corrective measures to reduce turbidity and phosphate to acceptable levels and increase the chloride content specifically suitable for catfish production. In this way, a healthy aquatic ecosystem, humans, and the environment can be guaranteed. Moreover, it is recommended to conduct regular monthly monitoring of the physico-chemical parameters for a period of one year (EMB-DENR, 2008) to account for seasonal differences and among other sources of variations.

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