Water parameters of Pulang Lupa Lake, an abandoned open pit mine in Puerto Princesa City, Palawan, Philippines and its potential as bird watching destination

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ABSTRACT

Abandoned open pit mines when properly managed can be an important settlement and eco-tourism sites. The Pulang Lupa Lake – an abandoned mercury open mining pit in Puerto Princesa City supports a number of settlers and important wildlife. With limited information about its status, this study was conducted to determine the lake's water quality and its potential for eco-tourism. Water physico-chemical parameters were within the permissible limits sets by the Department of Environment and Natural Resources for Class C water during the rainy but not in summer season. Water samples for both seasons were positive for total and fecal coliform. The lake serves as important source of fish for informal settlers and the presence of several bird species makes it a potential bird watcher's destination. Information and education campaign among the residents around the lake and strategic environmental plans are needed for its sustainable utilization.

Keywords: water quality, fish species, Pulang Lupa Lake

INTRODUCTION

In the Philippines, several large-scale mines have been shut down in the past three decades because of economic loss, labour disputes, or a rejected mining application. However, none of these mines were rehabilitated right after closure. There are 20 abandoned mines across the country which may bring harm to the environment, animals and human being (Ilagan 2008). Unless proper mitigation and corrective actions are undertaken, the surrounding population and receiving environment will be continuously exposed to both chemical and physical risks from these abandoned mines (Ilagan 2008; Raymundo 2014).

Abandoned open pit mines can be created into a lake for a variety of purpose (Gammons et al. 2009). The Pulang Lupa Lake, an abandoned quicksilver open pit mine, serves as a fishing and recreation area for a

number of families in Bgy. Santa Lourdes, Puerto Princesa City. The uncontrolled activities of the settlers may cause further deterioration of the lake, thus the need to document its status and other potentials.

This study sought to determine the (1) physico-chemical parameters (water and air temperature, dissolved oxygen, total dissolved solids, suspended solids, turbidity, pH, phosphates and nitrates), (2) total coliform and fecal coliform and (3) fish and avifauna in Pulang Lupa Lake.

METHODS

Locale of the Study

Pulang Lupa Lake, geographically located at 9°50'0"N and 118°43'29"E, is an 8.7 ha abandoned mined pit situated at the southeastern part of Bgy. Santa Lourdes, Puerto Princesa City (Figure 1), Palawan, Philippines. It is bounded in the north by the City Solid Waste Management, in the west by Santa Lourdes Elementary School, in the east by a deforested hill and in the south, by clusters of households. The lake is about 4 km away from Honda Bay, a popular island hopping tourist destination. About 400 individuals belonging to 25 households reside along the shore of the lake. Wastes of domestic animals raised in each household are directly drained into the lake.

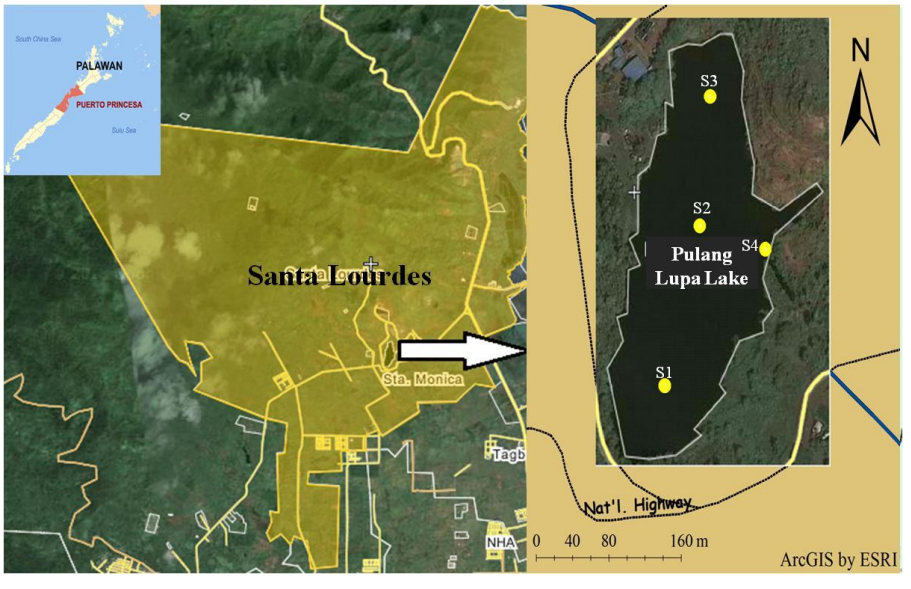

Figure 1. The location of Pulang Lupa Lake at Bgy. Santa Lourdes, Puerto Princesa City. Palawan.

Sampling Procedure

Four sampling sites were selected (Figure 1). Sampling was conducted in January (Garagara 2014) and May 2014. All samples were collected using a depth-integrated grab sample method. Water samples were kept in 350 ml plastic bottles for physico-chemical analysis and 250 ml decontaminated bottles for bacteriological analysis and stored in an ice chest before transporting to the laboratory. Samples of different fish species were obtained from residents who fish in the lake. Photos of common birds were taken during the sampling periods. Identification of fishes was based on the works of Matillano 2002; Delijero 2012; Gabuat 2013. Birds were identified using the works of Kennedy et al. 2000; Hutchinson and Villa 2014.

Laboratory Analysis

For tests on physico-chemical parameters, the spectrophotometric method was used. Using Portable Data logging Spectrophotometer, the suspended solids, turbidity, phosphate and nitrate -concentration of water samples were determined; pH meter for pH and conductivity meter in measuring the total dissolved solids (Eaton et al. 2005). Multiple tube fermentation technique was used to analyze the total and fecal coliform of water (Eaton et al. 2005; Bitton 1994). The coliform density was calculated in terms of most probable numbers (MPN) technique (Bitton 1994).

Data Analysis

Averages (±sd) of the gathered data were computed and compared against the standard set by DAO 34, S. 1990 (DENR 1990). Data in wet season were compared against dry season using T-test.

RESULTS AND DISCUSSION

Physico-chemical Characteristics of Pulang Lupa Lake

The ranges of water temperature in January (between 27.32°C and 29.06°C) were relatively lower than in May (28.65°C and 32.60°C) (Figure 2). The air temperature ranged between 26.60°C to 28.70°C and 27.50°C to 32.80°C of the same months, respectively.

The mean water temperature in summer (31.49°C) is significantly higher ($P<0.05$) than in rainy season (28.05°C) but there is no significant difference ($P>0.05$) between the air temperature in dry and wet seasons.

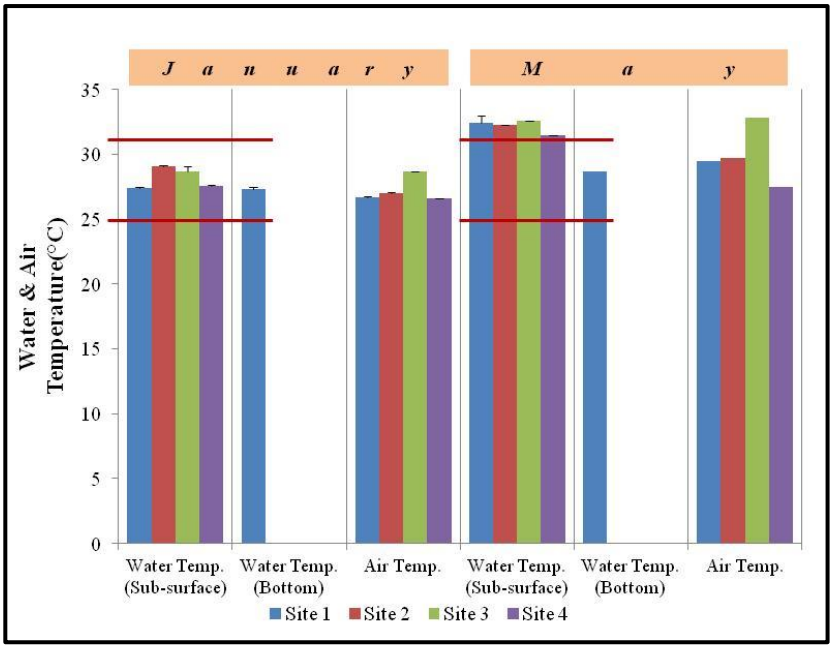

Figure 2. Average (±sd) water and air temperatures (°C) at four sampling sites in Pulang Lupa Lake. The red horizontal lines represent the maximum and minimum temperature in Class C body of water (DENR 1990).

The variation in temperatures could be the effect of the surrounding condition of the area (Lewis 1984), depth of the water (Michaud 1991; Johnson et al. 1999) and the presence of the vegetation canopy (Johnson et al. 1999).

The average range of DO concentration (Figure 3) in sub-surface and bottom layer ranged from 6.65 $mg.L^{-1}$ to 7.9l $mg.L^{-1}$. There is no significant difference ($P>0.05$) between the DO in dry and wet seasons. These values are far above the minimum limit (5 $mg.L^{-1}$) and are able to sustain aquatic life (Hallare et al. 2009). However, if domestic wastes are continuously thrown into the lake, the DO could become too low to sustain life especially fish in the future.

Total dissolved solids (TDS) in Pulang Lupa Lake ranged from 294.33 $mg.L^{-1}$ to 313.3 $mg.L^{-1}$ in January and 315 $mg.L^{-1}$ to 322 $mg.L^{-1}$ in May (Figure 4). The mean TDS in summer (317.6 $mg.L^{-1}$) is significantly higher than in rainy season (301.07 $mg.L^{-1}$). There was a little fluctuation in January than in May. There is no standard set for TDS in DAO 34 (DENR 1990). Thus, these levels are acceptable for a lake.

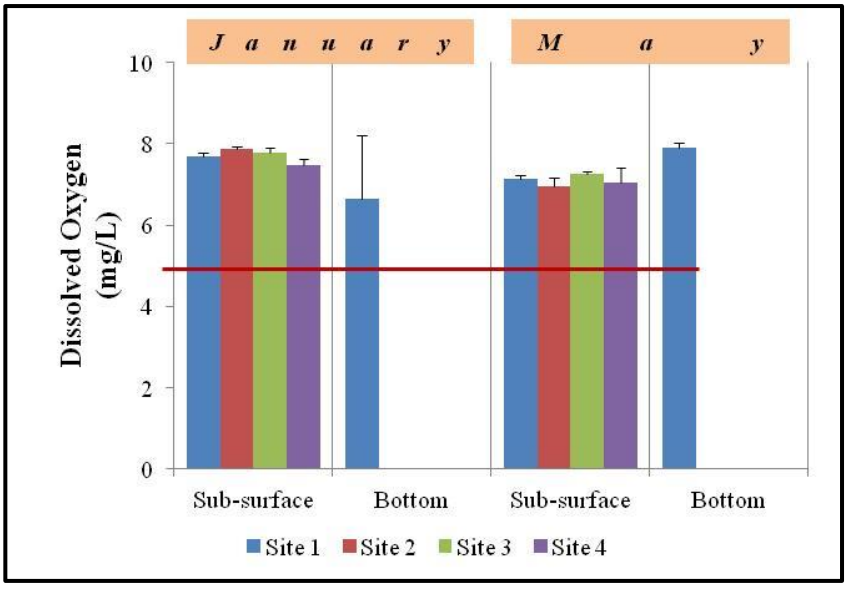

Figure 3. Average (±sd) dissolved oxygen concentration (mg.L^{-1}) at four sampling sites in Pulang Lupa Lake. The red horizontal line represents the minimum level of DO in Class C body of water (DENR 1990).

The variations in TDS concentrations often results from industrial effluent, changes to the water balance by increased water use or increased precipitation (Scannell and Duffy 2007). Run-off from the agricultural farms surrounding the lake can also increase the concentrations of TDS.

The suspended solids (SS) were relatively the same among sites except in one of the sites in May (Figure 5). There is no significant difference ($P>0.05$) between the suspended solids in dry and wet seasons. The suspended solids levels were within the maximum required standard for TSS of Class C water at 65 mg.L^{-1} (DENR 1990).

Suspended solids indicate the extent of sedimentation resulting from land-based activities which can reduce the light penetration and photosynthetic activities of aquatic plants (National Water Quality Status Report 2005). Silt, stirred up bottom sediment, decaying plant matter, or sewage treatment effluent can also contribute to high suspended solids (Johnson et al. 1999). It is also possible that the water is more concentrated with domestic wastes in May because of the dry season than in January where it is diluted with rain.

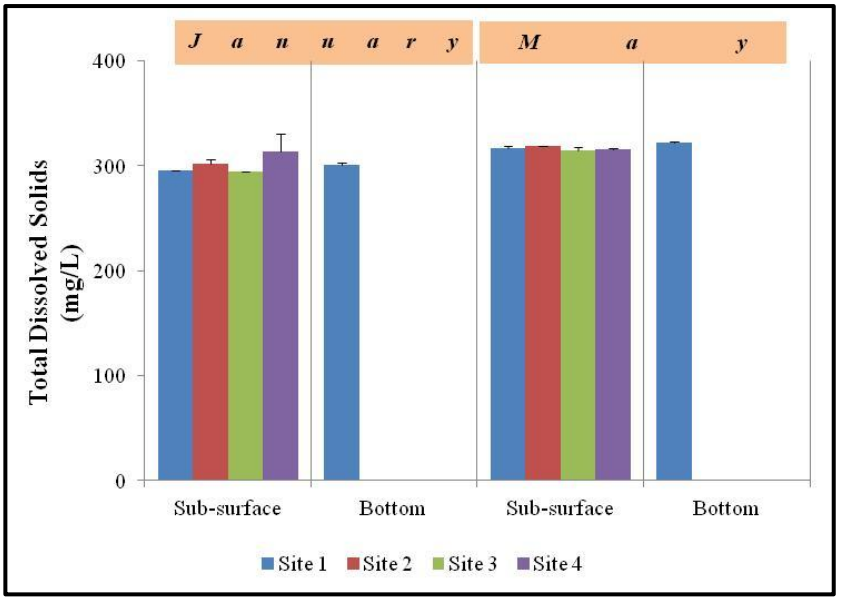

Figure 4. Average (±sd) total dissolved solids (TDS) values at four sampling sites in Pulang Lupa Lake.

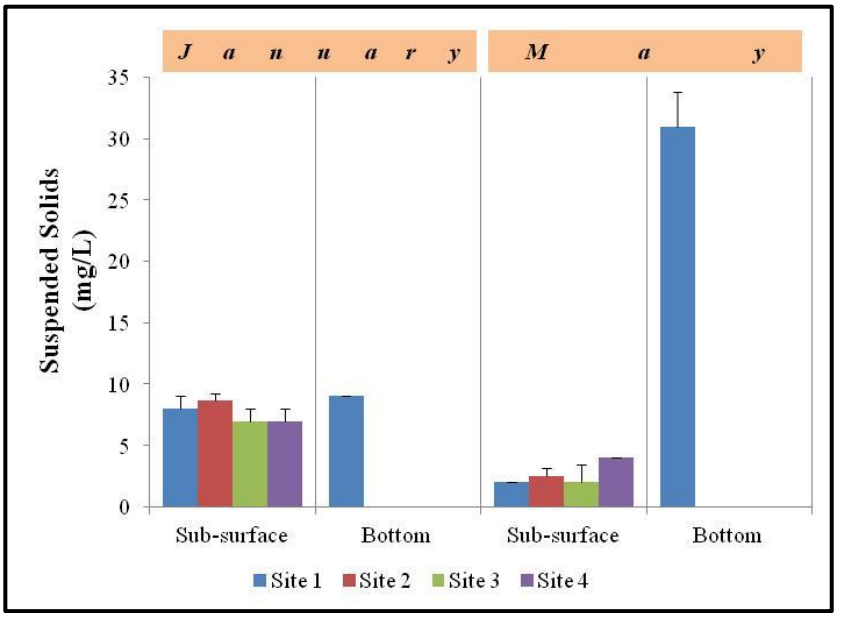

Figure 5. Average (±sd) suspended solids (SS) values at four sampling sites in Pulang Lupa Lake.

The turbidity (Figure 6) ranged between 2.5 FTU to 48 FTU. There is no significant difference (P>0.05) between the turbidity in dry and wet seasons. Turbidity was not considered as one of the parameters in DAO 34 (DENR 1990). Thus, it is anticipated that these levels are suitable for a lake.

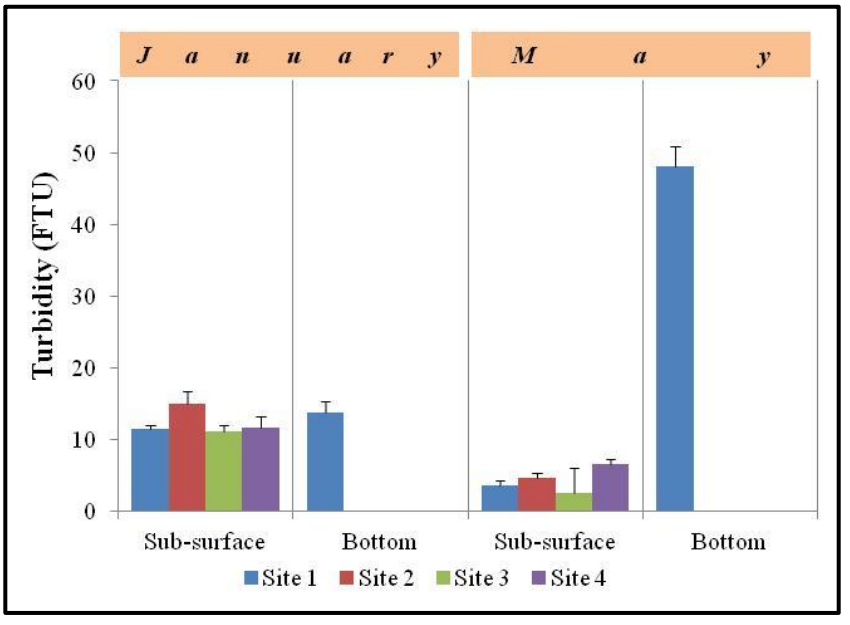

Figure 6. Average (±sd) turbidity (Formazin Turbidity Unit-FTU) values at four sampling sites in Pulang Lupa Lake.

The trend of turbidity is similar to the high suspended solids as discussed above. According to Zafaralla et al. (2005), when a lake is critically turbid, algae do not grow very well in its water. High turbidity decreases the amount of sunlight that penetrates the water thereby decreasing the rate of photosynthesis (Johnson et al. 1999). The observed gradual increase of turbidity in May at the bottom layer might be caused by the abundant of bottom dwelling organisms stirring up the sediment.

The recorded pH variation among sites in January was between 7.56 and 7.63 and it increased up to a range of 8.77 to 10.49 in May (Figure 7). There is no significant difference (P>0.05) between the pH in dry and wet seasons. The high pH value in May which exceeds DAO 34, S. 1990 (DENR 1990) standard for Class C water could be due to increasing concentration of domestic sewage and waste water containing detergent from nearby households.

The fluctuation of pH (Figure 7) may be due to the photosynthesis by algae and other aquatic plants, watershed run-off and other factors (Hudson

1998). The significant increase of pH in May which reaches up to 10.5 can be lethal to other living organisms especially fishes if the exposure is prolonged (Johnson et al. 1999).

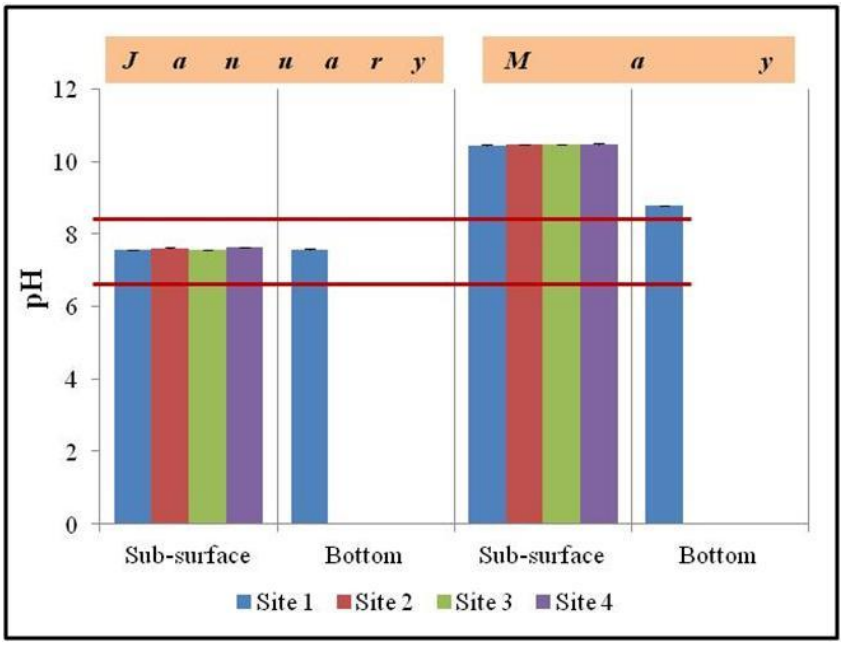

Figure 7. Average (±sd) pH values at four sampling sites in Pulang Lupa Lake. The red horizontal lines represent the maximum and minimum level of pH in Class C body of water (DENR 1990).

The variation of pH can also be attributed to the enrichment of nutrients and the clarity of the lake which indicate that there are decomposing organic matters at the bottom (Addy et al. 2004).

The average variations of phosphate among four sites fall below the maximum level for Class C water (DENR 1990) except in one station in May (Figure 8). Domestic and agricultural wastes can increase the naturally occurring phosphorus in the water (Martinez and Galera 2011). Phosphorus concentration determines the level of eutrophication of the lake or the increase of plants and algal growth due to the excess of nutrients (Johnson et al. 1999).

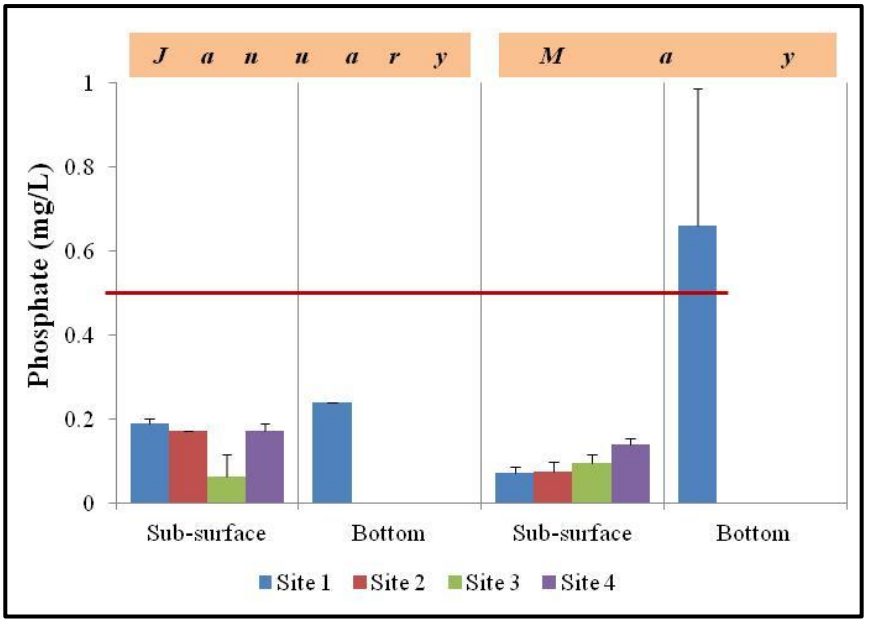

Figure 8. Average (±sd) phosphate concentrations (mg.L^{-1}) at four sampling sites in Pulang Lupa Lake. The red horizontal lines represent the maximum and minimum level of phosphate in Class C body of water (DENR 1990).

The nitrate concentration of Pulang Lupa Lake varies between 0.83 mg.L^{-1} and 6.40 mg.L^{-1} in January while it varies between 3.05 mg.L^{-1} and 4.1 mg.L^{-1} in May (Figure 9). There is no significant difference (P>0.05) between the nitrate in dry and wet seasons. Discharge from agricultural farms and/or domestic wastes could have caused the high level of nitrate particularly at site 4. High nitrate concentrations in the water can contribute to eutrophication and are often accompanied with an unpleasant odor and water taste. It reduces the water clarity as well (Johnson et al. 1999). While nitrate levels in four sites were within the DAO 34, S. 1990 standard (10.0 mg.L^{-1}) (DENR 1990), nitrate concentration may trigger algal growth which might lead to early eutrophication of the lake if loading will continue unabated.

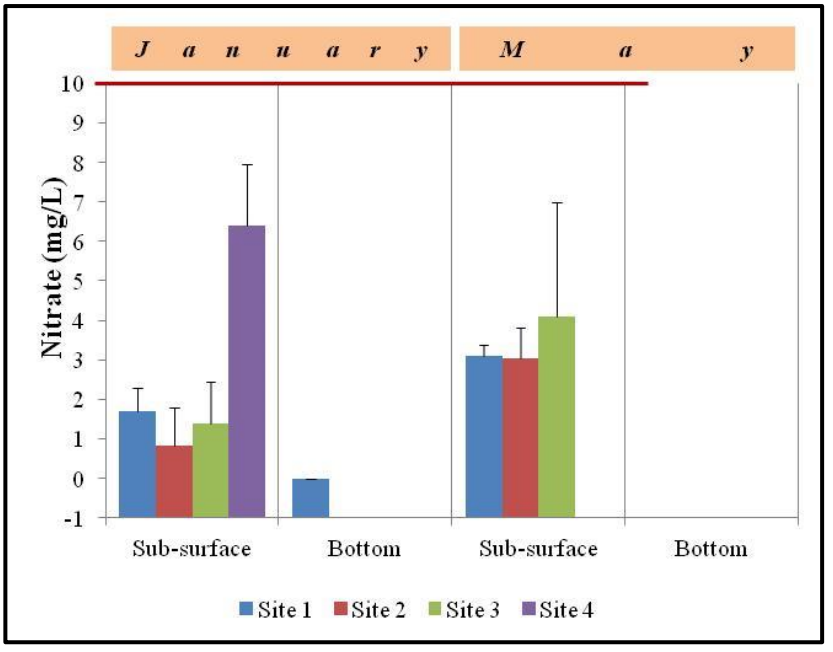

Figure 9. Average (±SD) nitrate concentrations (mg.L^{-1}) at four sampling sites in Pulang Lupa Lake. The red horizontal line represents the maximum level of nitrate in Class C body of water (DENR 1990).

Bacteriological Characteristics of Pulang Lupa Lake

Pulang Lupa Lake was positive for both total coliform and fecal coliform tests. Total coliform and fecal coliform counts of water samples from all sites were >8.0 MPN.100 ml^{-1} (Table 1).

The establishments of pigpens (National Water Quality Status Report 2005), vicinity of solid waste management (SWM), discharges of sewage from small establishments and the proximity of local communities that directly discharge organic and or inorganic wastes into the lake could have contributed for the presence of pathogenic and non-pathogenic bacteria in the water (Water Stewardship Information Series 2007; Swistock 2010).

Fecal coliforms are high during storm water run-off from urbanized areas because of the presence of disintegrating storm and sanitary sewers, misplaced sewer pipes and good breeding conditions (Michaud 1991; Swistock 2010). Children playing/swimming on the lake may accidentally ingest coliform contaminated water and may suffer from various stomach and intestinal illness and even death (Water Stewardship Information Series 2007). Provision of sanitary facilities and education campaign is needed to address these problems (Sagun 2012).

Table 1. Bacteriological Characteristics of Pulang Lupa Lake at Bgy. Santa. Lourdes, Puerto Princesa City.

Samples	Total Coliform Test MPN/100mL	Fecal Coliform Test MPN/100mL
Station1 (bottom)	>8.0	>8.0
Station1 (surface)	>8.0	>8.0
Station 2	>8.0	>8.0
Station 3	>8.0	>8.0
Station 4	>8.0	>8.0
DAO 34, S. 1990 (DENR 1990)	5,000	-

Fish and Avifauna in the Lake

Fishes found in the lake include *Oreochromis niloticus*, *Puntius binotatus* and *Chana striata* (Figure 10). Most of these are caught by hook-and-line, spear gun and fish nets. The estimated fish catch of each fisherman is about 20 kg a month. Considering that 20 fishermen fish in the area, a total of 4,800 kg of fish per year is harvested from the lake. The fishes caught in the lake are either used for personal consumption, or sold as fresh or dried in the market. Dried fishes from the lake are also transported and sold in other cities.

The volume of fish catch depends upon weather conditions. During heavy downpour, the water gets turbid and the catch is high as fish tends to move to the surface to get enough oxygen while during summer, fishes in the lake are few (Mr. Tony Marshall, pers. comm.).

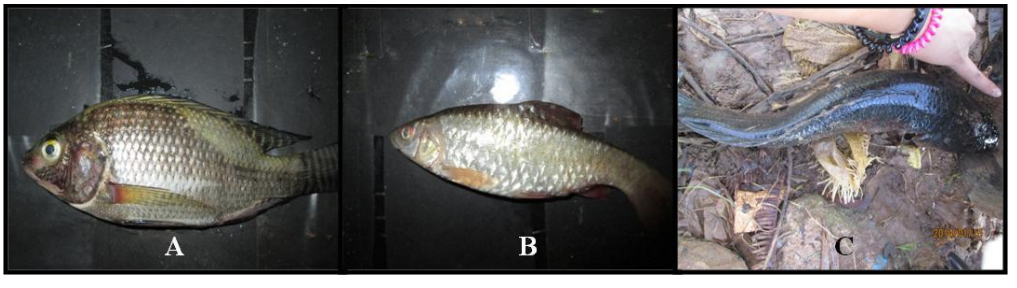

Figure 10. Some of the fish species caught in the Pulang Lupa Lake. A. Tilapia (*Oreochromis niloticus*), B. Carp (*Puntius binotatus*), and C. Mudfish (*Chana striata*).

Documented bird species in the lake included *Nycticorax caledonicus*, *Nycticorax nycticorax*, *Haliastur indus*, *Egretta intermedia*, *Anas platyrhynchos*, and *Geopelia striata* (Figure 11). Most of these have been seen roosting at the known beaches of Palawan (Kennedy et al. 2000; Hutchinson and Villa 2014).

These birds are feeding on the variety of animals in the lake including fish. Some of these are sometimes trapped on the submerged fish nets. There were also some sunbirds and bulbul (Hutchinson and Villa 2014) but these were not photo-documented.

CONCLUSION

Most measured water physico-chemical parameters were within the DAO 34, S. 1990 standards (DENR 1990), however, domestic and agricultural wastes could have contributed to the enrichment and turbidity of lake. The enrichment of the lake is depicted by the positive results of the total and fecal coliform. The presence of fish and wildlife such as birds makes the lake a potential spot for tourists especially among bird watchers.

RECOMMENDATIONS

There is a need to disseminate information about the status of the lake. Community residing within its periphery must be informed of the hazard brought about by improper waste disposal. Habitat restoration can be done to conserve wildlife. Intensive survey of fish and other fauna is also recommended to reflect the true value and importance of the lake. Considering that the lake was a mine pit, it is important to determine the mercury level in the water and fishes. The presence of a number of bird species makes the lake a potential sanctuary and birding destination. Policies are needed to avoid further damaging impacts of the settlers into the lake, and prevention of further effects of any contaminants on the environment, the residents and the wildlife in Pulang Lupa Lake.

ACKNOWLEDGEMENTS

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Figure 11. Some species of birds in Pulang Lupa Lake. A. Rufous Night-heron (*Nycticorax caledonicus*), B. Black-crowned Night-heron (*Nycticorax nycticorax*), C. Brahminy Kite (*Haliastur indus*), D. Intermediate Egret (*Egretta intermedia*), E. Mallard (*Anas platyrhynchos*), F. Zebra Dove (*Geopelia striata*).

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