# TROPHIC STATE OF LAKE PETÉN ITZÁ, GUATEMALA

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## ABSTRACT

Trophic state and levels of contamination in Lake Petén Itzá were assessed in this study. Water and sediments have been sampled quarterly each year during 2004-2006. N-$NO_3$ and P-$PO_4$ showed mean concentrations above 500 μg/L and 50 μg/L, respectively, in sites near towns and Ixlú River, in levels corresponding to eutrophic lakes. Ammonia showed levels that could represent risk to the ecology in sites near towns. Chromium, lead and cadmium showed relatively high concentrations in sediments, especially in Ixlú River, with high portion of available form. Endemic fish individuals (*Petenia splendida)* analyzed in this study showed levels of lead and mercury, and organochlorine pesticides (*p,p´*-DDT 0.7-1.2 ng/g; *p,p´*-DDE 5.4-20.2 ng/g), that should be considered, as this fish is prepared in traditional dishes. Total and fecal coliforms, and *Escherichia coli* were found in water of all sampling sites. The results showed that the eutrophic state and contamination have extended recently to different sites in Lake Petén Itzá.

## INTRODUCTION

Lake Petén Itzá (16°54`00”N and 89°41´41” W) is located in lowlands of the Department of Petén at 110 m above sea level, within the Maya Biosphere Reserve. The Lake has an area of 100 $Km^2$ and 160 m maximum depth and its basin (1200 $Km^2$) is characterized by low-lying karsted limestones of Cretaceous and Tertiary age (Vinson, 1962) and classified as Tropical Wet Forest Bioma and Subtropical Wet Forest according to Holdridge Life Zones classification (Barrios, 1995). Lake Petén Itzá has not surface effluents. The Department of Petén has overcame a demographical explosion since the 1960s, registering an increment in population from 25000 people to more than one-half million living nowadays in Petén. This has represented an important pressure on the ecological integrity of the ecosystems, which can be observed in Lake Petén Itzá basin. Forest loss, intensive agriculture, ranching and direct sewage discharges from the main towns in the basin (Flores, San Benito and Santa Elena), have increesad the inputs of nutrients and pollutants to the lake leading to an increment in the lake eutrophication process.

Previous paleolimnlogical studies using Pb-210 in the south of Lake Petén Itzá showed recent eutrophication (Rosenmeier *et al.*, 2004). Changes in the sedimentation rate were found to be correlatos with the increase of human population density, suggesting that the changes i the sediment records are caused by anthropogenic activities. The wastewater discharges from Flores, Santa Elena and San Benito villages have increased the concentration of nutirents. The study revealed that in 2002 the eutrophic state was restricted to the south of the basin, but it could be extended due to the increasing human population. This was confirmed in this work.

The aim of this study was to evaluate the water quality in Lake Petén Itzá in order to provide relevant information for making decisions related with water resources management and to improve the knowledge regarding the biogeochemical processes in the Lake.

## METHODOLOGY

Water and sediments were sampled quarterly each year since 2004, in seventeen sites in Lake Petén Itzá (Table 1). Sampling sites were selected near towns and affluents, and three center lake sites as control. Water physicochemical and bacteriological analyses were made according to APHA-AWWA methodology (APHA, 1998). Metal in sediments were analyzed by Atomic Absorption Spectrophotometry (AAS). Toxic metals and organochlorine pesticides were analyzed in individuals of *Petenia splendida* endemic fish by AAS and gas chromatography with ECD.

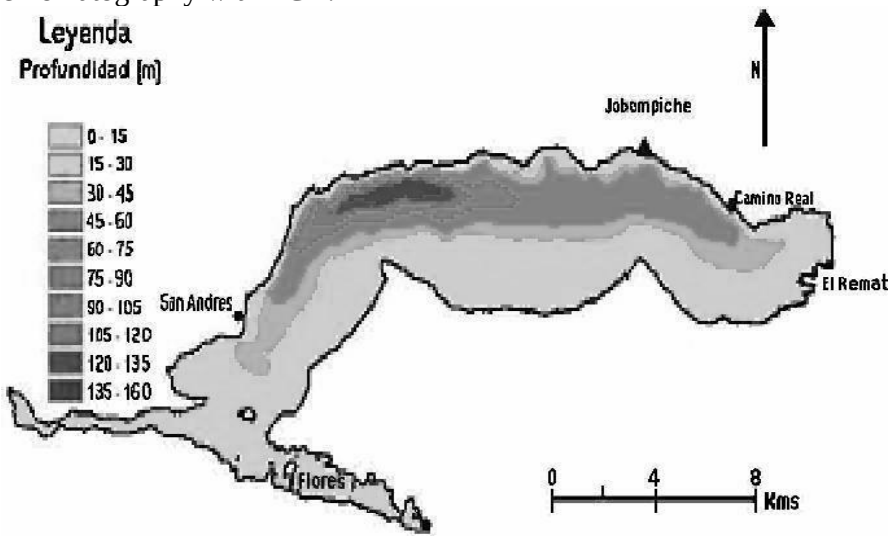


Figure 1. Sampling sites in Lake Petén Itzá.

## RESULTS AND DISCUSSION

Nutrients levels found in Lake Petén Itzá in this study correspond to eutrophic lakes, as can be seen in Table 1. $N\text{-}NO_3$ was found in mean concentrations above 500 μg/L and $P\text{-}PO_4$ showed mean concentrations above 50 μg/L especially in sites near towns and Ixlú River. This was confirmed by the presence of eutrophic and hypereutrophic phytoplankton organisms found in the study (cyanophytes, chlorophytes and diatoms).

The highest mean concentration of $N\text{-}NO_3$ was found in June 2004 (1.186 mg/L), which is characteristic of eutrophic lakes. This value could be due to the beginning of the rainy season, when a higher load of soil superficial nutrients are washed by the rain. Nitrite is considered as a good indicator of recent contamination. All sampling sites showed $N\text{-}NO_2$ levels lower than 10 mg/L. No significant differences for $N\text{-}NO_2$ were observed between the months of sampling. $N\text{-}NH_4$ is a good indicator of recent contamination and it represents risks to the ecology and human health, as ammonia, which was found in high concentrations in sites near towns. High pH values shifts the equilibrium between ammonia and ammonium towards ammonia form, which is toxic for fish. The $N\text{-}NH_4$ concentration was higher than the guide value of the World Health Organization for drinking water (0.050 mg/L) at different

months in several sampling sites (River Ixlú, San Andrés, San José, Tres Naciones, San Benito and Santa Elena). The sampling site in Santa Elena showed $N\text{-}NH_4$ higher than 0.050 mg/L in Abril and June 2004 and January 2005 (0.168, 0.091 y 0.063 mg/L respectively). Thus $N\text{-}NH_4$ could be considered as a main indicator of contamination in Lake Petén Itzá.

**Table 1. Mean concentrations of physicochemical water quality parameters in Lake Petén Itzá along the study.**

| *Nr.* | *Sampling site* | *T (°C)* | *pH* | *$N\text{-}NO_3$ (mg/L)* | *$N\text{-}NH_4$ (μg/L)* | *$N\text{-}NO_2$ (μg/L)* | *$P\text{-}PO_4$ (mg/L)* |
|---|---|---|---|---|---|---|---|
| 1 | Rio Ixlú | **29.1** | **7.94** | **0.63** | **25** | **2** | **0.06** |
| 2 | La Chingada | **29.3** | **7.95** | **0.69** | **21** | **2** | **0.05** |
| 3 | San Andrés | **29.2** | **8.23** | **0.69** | **31** | **3** | **0.07** |
| 4 | San José | **29.3** | **8.23** | **0.69** | **27** | **2** | **0.06** |
| 5 | San Pedro | **29.4** | **8.12** | **0.70** | **18** | **2** | **0.08** |
| 6 | Jobompiche | **29.1** | **8.24** | **0.81** | **16** | **3** | **0.05** |
| 7 | Cerro Cahuí | **28.8** | **8.13** | **0.73** | **18** | **2** | **0.04** |
| 8 | El Remate | **28.8** | **8.00** | **0.78** | **25** | **3** | **0.05** |
| 9 | Tres Naciones | **28.9** | **8.11** | **0.61** | **41** | **2** | **0.05** |
| 10 | South center | **28.7** | **8.07** | **0.60** | **36** | **4** | **0.03** |
| 11 | Lake center | **29.0** | **8.20** | **0.71** | **25** | **1** | **0.04** |
| 12 | West center | **28.9** | **7.94** | **0.77** | **24** | **7** | **0.03** |
| 13 | Le Pet | **29.1** | **8.30** | **0.68** | **24** | **2** | **0.05** |
| 14 | San Benito | **28.8** | **8.28** | **0.65** | **36** | **2** | **0.05** |
| 15 | Santa Elena | **28.8** | **8.25** | **0.60** | **77** | **2** | **0.04** |
| 16 | Aeropuerto | **28.7** | **8.28** | **0.75** | **23** | **2** | **0.03** |
| 17 | San Miguel | **29.1** | **8.25** | **0.63** | **24** | **3** | **0.03** |

The highest levels of $P\text{-}PO_4$ were found in October and December in 2004 and 2005, when almost all the sampling sites showed levels higher than 20 μg/L which corresponds to eutrophic lakes (Machorro, 1996). Jobompiche, San Benito and El Remate were the sampling sites that showed the highest levels of $P\text{-}PO_4$. These sites are contaminated by wastewater discharges from villages near the area.

**Table 2. Total and available mean concentrations of metals in sediments of Lake Petén Itzá (mg/g dw)**

| **Metal** | **Punta Nimá** | **Centro Sur** | **Tres Naciones** | **Río Ixlú** | **El Remate** |
|---|---|---|---|---|---|
| Zn (A) | 0.6 | 0.9 | 0.3 | 4.3 | 0.2 |
| Zn (T) | 5.1 | 14.8 | 74 | 22.9 | 13.3 |
| Ni (A) | 0.1 | 1.1 | 0.6 | 1.9 | 0.3 |
| Ni (T) | 3.5 | 10.1 | 5.4 | 8.8 | 7.3 |
| Mn (A) | 38.0 | 63.4 | 63.4 | 76.9 | 39.2 |
| Mn (T) | 672.3 | 1091.6 | 97.3 | 214.5 | 57.1 |
| Cr (A) | 4.8 | 4.6 | 6.5 | 7.9 | 8.3 |
| Cr (T) | 20.3 | 19.6 | 9.6 | 18.5 | 16.7 |
| Pb (A) | 2.2 | 5.1 | 1.6 | 6.4 | 1.3 |
| Pb (T) | 4.7 | 5.3 | 4.4 | 7.0 | 1.8 |
| Cu (A) | 0.01 | 0.11 | 0 | 0.22 | 0.01 |
| Cu (T) | 0.55 | 0.67 | 0.46 | 0.78 | 0.55 |
| Cd (A) | 0.05 | 1.3 | 0.4 | 2.5 | 0.2 |
| Cd (T) | 0.79 | 6.7 | 1.8 | 20.7 | 2.2 |
| Fe (A) | 48.4 | 236.8 | 16.5 | 251.2 | 20.5 |
| Fe (T) | 1920.2 | 8022.9 | 2492.9 | 12948.0 | 1677.4 |

**A: available; T: Total.**

Chromium and cadmium showed relative high concentrations in sediments from the lake (Table 2), especially in Ixlú River, with high portion of available form, indicating some risk for entering into the thropic chain by sediment resuspension. Individuals of the endemic fish species *Petenia splendida,* analyzed in this study, showed levels of toxic metals (lead and mercury) and organochlorine pesticides (*p,p´*-DDT 0.7-1.2 ng/g; *p,p´*-DDE 5.4-20.2 ng/g and *p,p´*-DDD 0.8-1.9 ng/g), that should be considered, as this fish is prepared in traditional dishes in Petén. Total and fecal coliforms, and *Escherichia coli* were found in water of all sampling sites. There results indicate that the contamination of water in Lake Petén Itzá represent riks for the human health, since the water is used for irrigation, recreation and human consumption.

Santa Elena, Flores, San Andrés, Jobompiche and El Remate sampling sites showed the highest levels of contamination, with nutrients in concentrations higher than those expected in natural waters, and corresponding to levels of eutrophic lakes.

## CONCLUSION

The water quality in Lake Petén Itzá is not appropriate for human consumption nor for recreation. The metal concentrations found in sediments of Lake Petén Itzá are important as baseline, since industrial and commercial activities are increasing quickly in towns in the basin. It is expected that levels of nutrients in Lake Petén Itzá continue to increase as human population growhts and while no seawage treatment be implemented in the towns surrounding the lake. Thus, it is important for government to make decisions regarding the installation of wastewater treatment plants in the short-term, especially in Santa Elena, San Benito and Flores.

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