

# The Contamination of Lake Atitlan, Its Implications and Possible Solutions

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## Introduction

Called by many "The most beautiful lake in the world", Lake Atitlan faces contamination that could jeopardize those whose livelihood depends on it. The economy around the lake depends mostly on two things: agriculture and tourism. Both of these industries depend extensively on the health of the lake, in two very different ways. About 20% of all the tourism in Guatemala is from people visiting Lago Atitlan, for its breathtaking views, volcano climbing, spas and the experience of the indigenous culture. However, due to the recent natural disasters (Hurricanes Stan and Agatha, 2005 and 2010 respectively) and increasing toxicity of the lake, the tourism industry has been under a severe strain. The agriculture industry is also under a severe amount of stress, but for slightly different reasons. The Mayan People that live around the lake have historically been agricultural societies, but in recent times, the focus has turned from subsistence farming towards cash crops (like coffee, avocados and corn). Additionally, as the populations around the lake grew in magnitude, the demand for land has sent people higher and higher up the mountains. Both of these facts leads to extensive problems for the lake-- contamination from the fertilizers, devastating mudslides from unstable soil.

## Geologic and Ecologic Importance of the Lake

Lake Atitlan is located in the highlands of Southwestern Guatemala. It is thought to be the deepest lake in Central America, with a depth of 342 meters. It is the second largest lake in Guatemala and was formed in a deep-sided collapse caldera about 84,000 years ago. Three active volcanoes surround the lake: Atitlan, San Pedro and Toliman. There is a set of well-defined northwest and northeast trending faults, with right- and left-lateral slip respectively, dominate the regional structure and control some sections of caldera boundary faults. Atitlan, Toliman and several smaller volcanic vents are aligned north-south. The lake was formed by an apparent south-southwestward migration of the locus of caldera formation in the Lake Atitlan region, and westward migration of caldera formation across western Guatemala, suggest slow movement of this small part of the Caribbean Plate east-southeastward relative to the Cocos-Caribbean subduction zone (Newhall 1987). It holds 24 km<sup>3</sup> of water and is located about 1500 kilometers above sea level. It is an endorheic lake, or one that does not flow out to a larger body of water (such as an ocean or sea). Due to the lack of outflow; it retains everything that flows into it (the major source of all of its problems). There are about 160 streams and rivers that discharge into the lake, but only 2 remain constant for the entire year. Because of its location in the highlands, Lake Atitlan is home to a semitropical climate. Temperature, precipitation, etc all vary with altitude. It has two major seasons: a wet season (May through October) and a dry season (November through April). Land cover around the lake is roughly 46% forest, 32% agriculture and the rest somewhat developed.

## History of the Region and the People

Approximately 200,000 people live in the highlands surrounding the lake, and 92% of those are indigenous Mayans. They are split into 3 main groups, due to their languages: Tzutujil, Kaqchikel and Quiche and distributed across 12 main towns. During the Guatemalan civil war (1960-1996), the lake was the scene of many terrible human rights abuses. Indigenous people were assumed to be universally supporters of the guerrillas who were fighting against the government, and were targeted. These practices have led to an attitude of distrust with regards to the federal and departmental (state) governments. The culture in general has extremely strong ties to the lake-- I was told by my host-father that it is the center of all that they do and the basis of their culture. It is a source of food, a source of livelihood and a source of recreation, just to name a few. However, due to their current practices, its health is in severe jeopardy.



Figure 1: Map of Guatemala, Lake Atitlan circled in Red

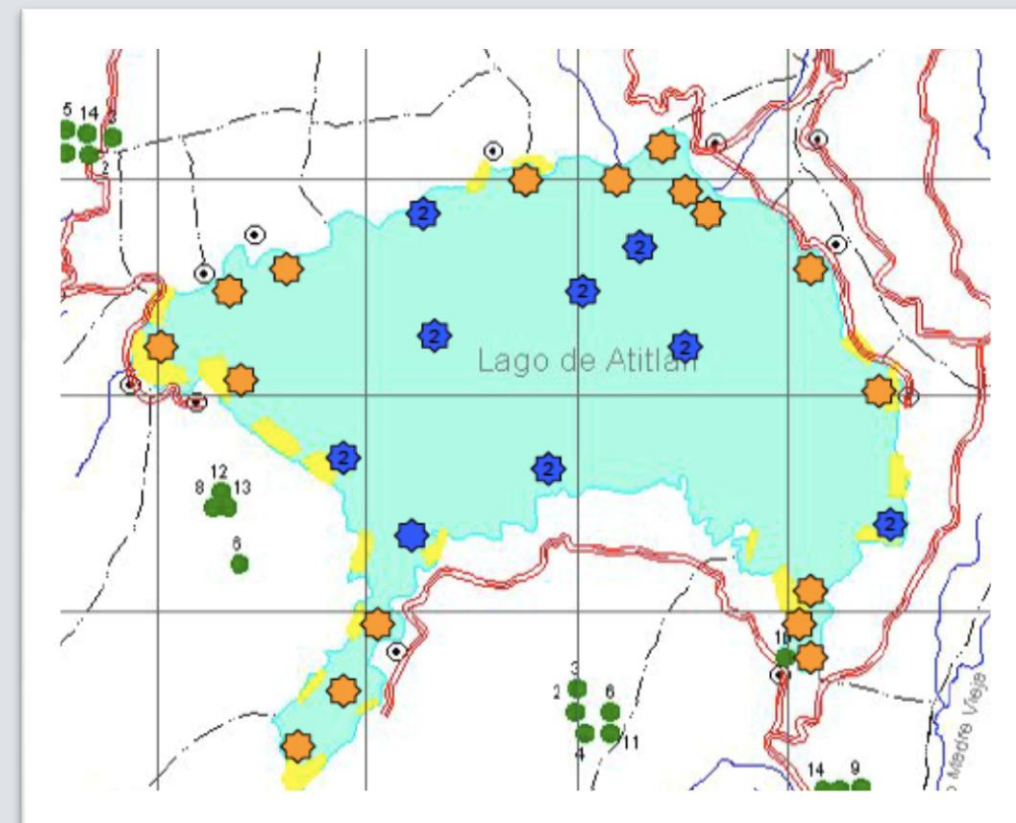


Figure 2: Monitoring stations throughout the lake. Giron 2009

Parameter	1968	1974	1983	2004
Nitrate	0.12	0	0.27	0.5
Phosphate	<0.15	0.03	0.10	0.09
Transparency	17	---	13.5	12.5

Figure 3: Nutrient Levels over time in the Lake. Giron 2009

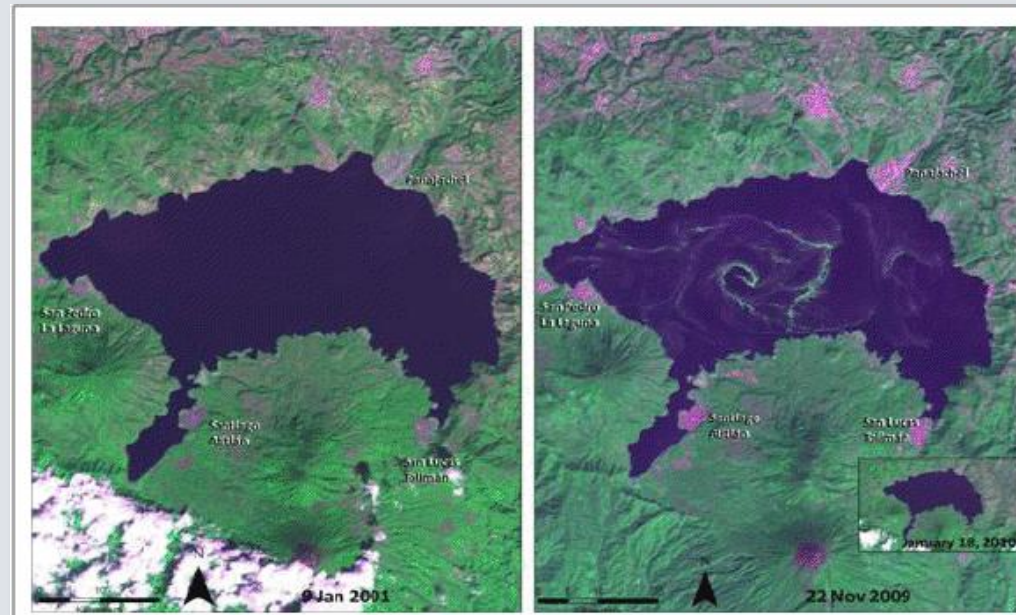


Figure 4: Cyanobacteria Bloom of 2009. Giron 2009

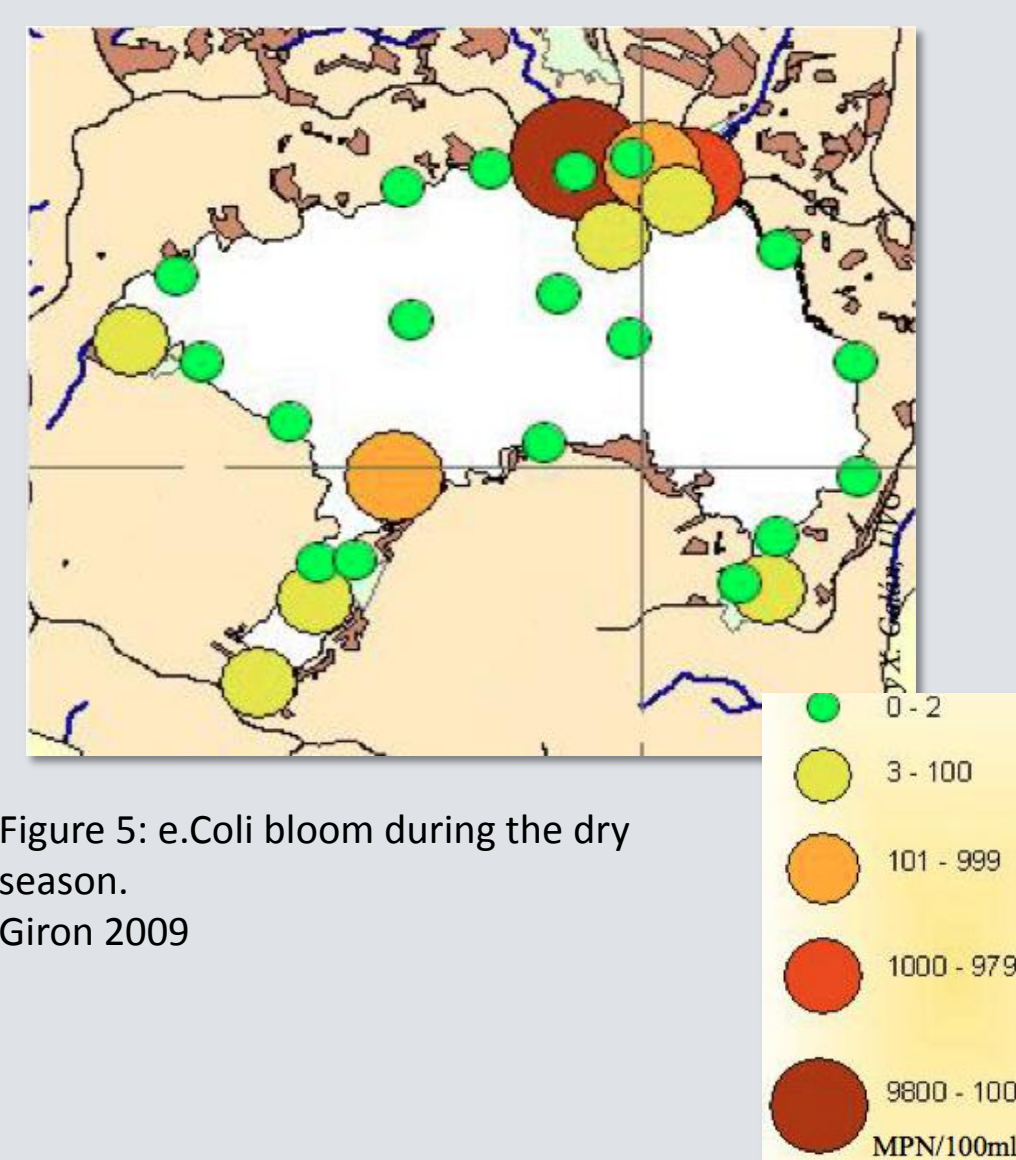


Figure 5: e.Coli bloom during the dry season. Giron 2009

## Current Lake Contamination

The quality of the lake water has been in steady decline for years. There are two major problems that the lake currently faces. First, the cyanobacteria blooms, which are result of the flow of nutrients into the lake. The second is the e. Coli , fecal coliform and other carious contaminants that are from the lack of wastewater treatment and the flow of raw sewage into the lake. A group of researchers from universities all over Guatemala started intensely monitoring the lake in 2002. Monitoring had been done before then, but never on this scale. Figure 2 demonstrates the 26 sites used, from the all areas of the lake (northern, eastern, central, southern, western and distanced to be exact.) Figure 3 compares the findings over time, exemplifying the deterioration over time as the population grew.

## Cyanobacteria

The first widespread cyanobacteria bloom was in December of 2008, and there was a second, more extensive one in October of 2009. The first bloom was extremely localized, and lake was cleared by the end of January 2009. The second bloom started in October, most likely due to upwelling, and spread quite rapidly. The bloom was formed *Lyngbya robusta* species of cyanobacteria and it was the first bloom of this specific species. The Figure to the right shows the cyanobacteria bloom at its peak, when it covered roughly 40% of the 137 km<sup>2</sup> lake area in 2009. This cyanobacteria was not toxic, but was extremely odorous and very unpleasant to observe. Research cite the uncontrolled nutrient inputs into the lake as the catalyst that sparked the bloom. Phosphorus levels were extremely high, and there was a low N:P ratio. As of now, the bloom has gone away, but there is still constant fear that another will return, since sampling has shown that the algae is still present in the surface waters of the lake.

## Sewage Inflow to the Lake

The other major problem that threatens the lack is the lack of wastewater treatment, and the amount of untreated sewage that flows into it every day. The sewage come via four different ways and is broken down as such: Solid Waste(62%), wastewater (30%), soap/detergents(4.5%) and oil/fossil combustibles(3.5%). The sewage reaches the lake through a variety of ways. The first and largest source is via the leaching from the seepage pits underneath the homes. Most of the homes in the region has a seepage pit underneath them, where wastewater is collected and allowed to seep back into the water table, and thus return to the lake. The major problem is that due to the porous volcanic nature of the rock, raw sewage also ends up seeping through the rock and contaminating the lake as well. Due to the expanding population around the lake that has been living there for thousands of years, a large amount of raw sewage has been seeping into the lake from these pits for an extended period of time. A small percentage of the municipalities collect wastewater from the homes of their citizens, but then it is subsequently released into the lake without any sort of treatment. The final way that sewage gets into the lake is runoff from the streets. There almost no form of stormwater management, so during the rainy seasons, the streets of the towns surrounding the lake flood and take massive amounts of debris and animal feces with them into the lake. The input of sewage into the lake has lead to extremely high e. Coli/fecal coliform values; especially around the major towns. The numbers get worse in the dry season, when there is not constant inflow of water to dilute the lake. The figure to the left demonstrates the e. Coli bloom during the said dry season. The contamination has gotten worse in recent years with the doubling of the population. A very small portion of towns around the lake have had basic wastewater treatment facilities, but many have failed or become overwhelmed.

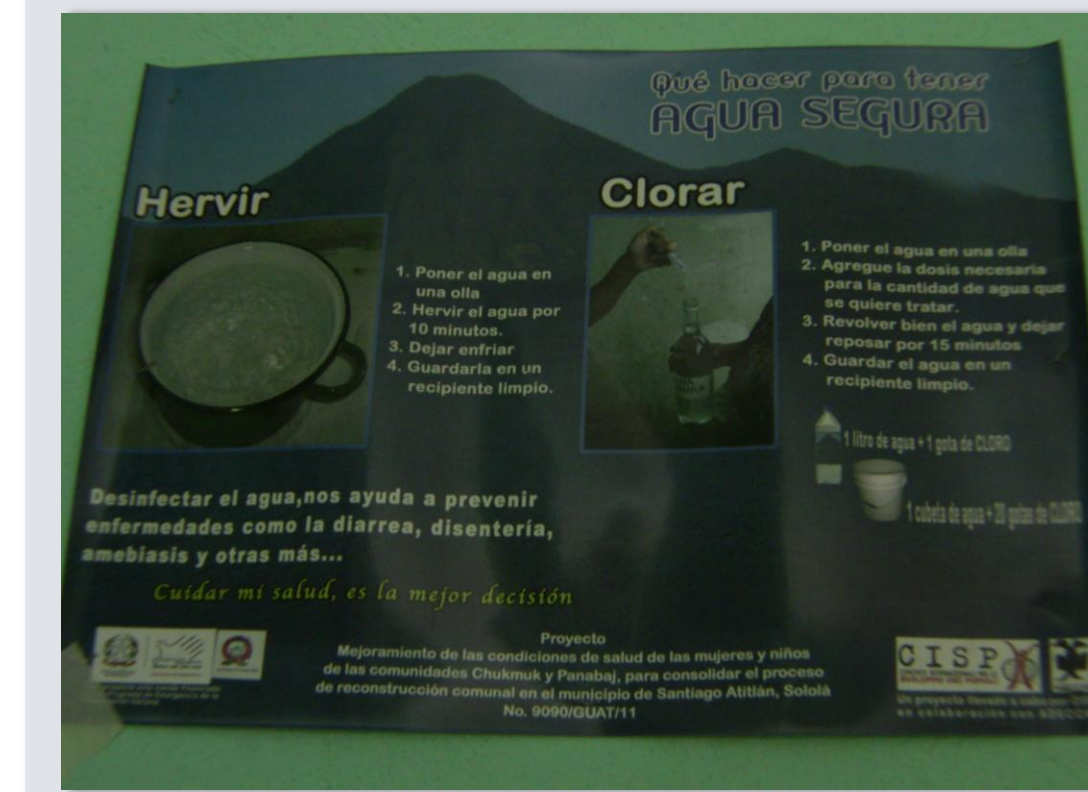


Figure 6: Sign warning people to boil and chlorinate their water so that they do not get sick. Murillo 2010



Figure 7: Women washing clothes in the Lake. Bose 2010

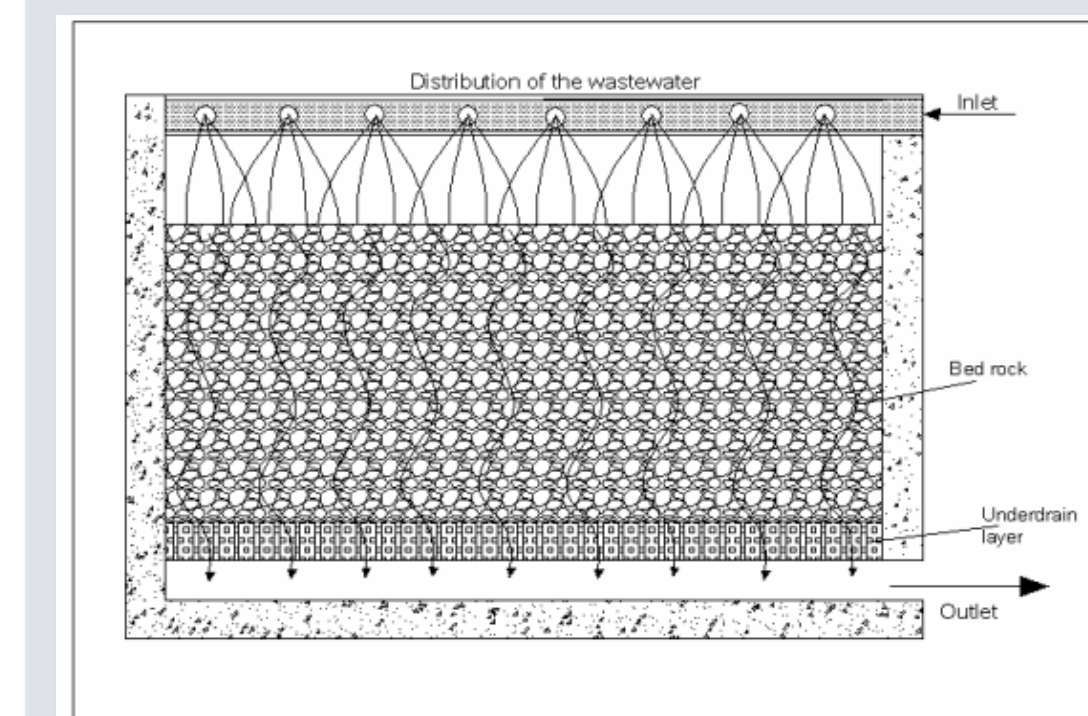


Figure 8: Basic Biofilter. Dobias and Leshhem 2008



Figure 9: The waters of Lake Atitlan



## Implications of the Contamination

Probably the most obvious way in which the contamination affects the lives of those living around the lake is the lack of drinkability. The lake water has been linked to several gastrointestinal illnesses, and so people are advised to not ingest it, untreated in any way. Currently, there are public service announcements throughout the town warning people of the dangers of drinking/cooking with the water and children are taught the value of clean water in school and church activities. Signs like the one to the left (Figure 6) are posted throughout the towns to raise awareness. Poorer families boil the water or chlorinate it before they drink it, though that does not always get rid of all the contaminants. Wealthier families buy jugs full of bottled water and use that for their cooking and drinking needs. Neither of these are actually solutions to the problems of the lake, but rather just ways to get around it. I have used journal entries from the Penn Guatemala Health Initiative database to determine how the contaminated lake affects peoples lives, and their view regarding water in general. Overall there is a large amount of false information, and disconnection from the citizens and the municipality. For instance, one woman stated that the Municipality chlorinated the water (she could smell it) , when that information is actually false. Other people say that the problem in the lake is from women washing their clothes in the lake, as demonstrated by Figure 7. The nation of Guatemala has made this endangered lake one of its top priorities, and has begun to dedicate money and resources with regards to fixing the problem. Additionally, there is a number of NGOs working in the area with regards to this issue as well. Collaboration and communication is needed at all levels to even begin to solve this problem.

## Possible Solutions

At first glance, the situation appears to be somewhat helpless. Implementation of a western wastewater treatment plant may be good in theory, but is probably not the best answer due to limited local knowledge and previous failures. With regards to the nutrient input, raising public awareness will most likely be the best knowledge. To make farmers aware that they can still make a profit while farming sustainable would hopefully result in less cash crops, lower fertilizer use and lower rates of soil erosion. If nutrients levels remain low, then the cyanobacteria problem/eutrophication can be managed. Due to the size of the lake and its surrounding population, many of the chemical and mechanical options for the sewage problem are not feasible. One idea that has become increasingly popular is the creation of wetland-like environments to filter the collected wastewater. This option is currently only feasible in municipalities where wastewater is collected. There is also the possibility of retrofitting homes so that sewage could be collected, but that would be an extremely expensive option. A more plausible one would be the installation of basic filtration systems in the seepage pit, to capture the bacteria before it gets transported through the rock. This can be seen in Figure 8.

## References

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