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Guatemala, Water and Sanitation

Eradicating Hydrilla from Lake Atitlán in Guatemala

Toxic algae blooms have become increasingly prevalent in Guatemala's Lake Atitlán watershed in the past decade. Recently, a carpet of algae enveloped over 75% of the lake's surface, posing a threat to nearby residents that depend on it for water and sanitation (Kruger 2021). In this paper, I argue that the herbicide Fluridone, the transition from synthetic to phosphorus-free fertilizers, and the teaching of efficient farming techniques can save Lake Atitlán.

Guatemala is a country in Central America that is located south of Mexico. Guatemala governs its citizens as a representative democratic republic, which means the population elects officials representing their political interests. According to the 2018 Guatemala census, 43.56% of the population is indigenous, including 41.66% Mayan, 1.77% Xinca, and 0.13% Garifuna (mixed African and indigenous). On the other hand, roughly 56% of the population is "non-Indigenous," referring to the Mestizo population with European ancestry. With approximately 18 million people residing in a little over 100 thousand square kilometers, Guatemala is the second-most densely populated nation in Central and South America (Nations Encyclopedia 2021).

Guatemala consists of various geological features such as volcanoes, mountains, rainforests, lakes, beaches, and ancient Mayan sites, which reflect its tropical climate. 43% of the land is agricultural, and 36% is forested, which creates a median farming space per household at about 1.24 acres (Lopez-Ridaura et al. 2019). Agriculture supplies about 23% of the GDP, offers upwards of 75% of export profits, and employs 50% labor. The primary cash crops are sugar, coffee, bananas, and cotton, followed by hemp, essential oils, and cacao (Nations Encyclopedia 2021). This makes Guatemala a suitable trading partner, given its resources. The average family size in Guatemala is about 4.8 individuals, approximately 2.2 individuals more than the United States (World Population Data Sheet 2020). Because about half of the population lives in a rural area, and the other in urban ones, food sources vary from local farms, grocery stores, and even subsistence farming. Corn is a staple in the Guatemalan diet, but often families cannot afford nutritious alternatives since two-thirds of the population lives on less than $2 a day (Thelwell 2018).

Even more concerning, the tap water in Guatemala is not safe to drink. This troubling situation is primarily due to poor infrastructure, pollution, population growth, lack of government funding, and Guatemala's unregulated water and sanitation sector (Rudick 2019). As a result, 95% of the water in Guatemala is dangerous to drink (Rudick 2019). Therefore, finding a long-term, effective solution will be one of the country's most pressing issues moving forward.

About 97% of Antigua's lakes and rivers, the country's epicenter for culture and history, are contaminated (Rudick 2019). Impure drinking water from these channels can lead to alarming digestive issues caused

by ingesting bacteria and parasites. In addition, kids and adults who do not have access to clean water suffer from conditions like diarrhea and cholera (Rudick 2019). Aside from just being uncomfortable, these conditions can also be fatal.

Nearly one in twenty Guatemalan children will die before age five from a lack of access to healthy water (Rudick 2019). The child mortality rate for Guatemala is about one in forty, which shows how dangerous the region around Lake Atitlán is compared to the rest of Guatemala. The water crisis also exacerbates situations for children in other ways. When children, especially those in rural areas with weaker sanitation infrastructure, get sick regularly from drinking unclean water, they have less established academic and social routines. This can have long-lasting effects on their educational development. To avoid this snowball effect, I propose a solution that focuses on improving the sanitation conditions for drinking water.

My proposed solution is to save Lake Atitlán from cultural eutrophication, which accounts for numerous algae blooms, the proliferation of invasive species, and a decline in fish abundance. Removing algae blooms will alleviate these problems and provide a safer source of clean water. The question is, what solutions can efficiently remove algae blooms to help solve for water and sanitation in Guatemala?

According to the WASH Rotary Action Group, a nonprofit organization that helps indigenous lake communities access clean water and sanitation, more than 400,000 Tz'utujil, Quiche, and Kaqchikel Maya people live near Lake Atitlán. Despite the contaminants, the residents in poverty around the lake have no other choice than to use the water for consumption and washing. More inferior water quality due to wastewater inputs has widespread impacts on the overall economy of the lake, losses in tourist attraction, reduced biodiversity, and increased health risks for those consuming the water (Schweitzer n.d.). Algae blooms arise from pollutants like phosphorus and E. coli in farming runoff and sewage (Thelwell 2021). Hydrilla, the most prominent perennial invasive aquatic plant in Lake Atitlán, poses a serious ecological threat (The California Department of Food and Agriculture 2010). Its ability to grow in various conditions gives it an advantage that allows it to out-compete native plants. Blue-green algae grow densely on these plants and create a high concentration of toxins in the water (Cornell Cooperative Extension 2020).

The herbicide Fluridone's utilization can eradicate Hydrilla in 30 to 90 days (Fluridone FAQ 2016). The New York State Department of Environmental Conservation (1994) stated that Fluridone is a slow-acting systemic herbicide that destroys nuisance or invasive submerged aquatic vegetation, including Hydrilla watermilfoil. The effectiveness is directly related to a plants' uptake rate and movement of compounds from foliage and roots to other tissues. U.S. Federal and state herbicide regulations and stringent treatment guidelines minimize exposure to non-target species. The Guatemalan government should recognize these regulations and policies when thinking about using Fluridone. No lasting negative impacts to waterfowl or wildlife have occurred due to Fluridone applied at or below the New York State accepted residual concentration of 50 ppb (NYSDEC 1994). Fluridone concentrations in fish species are considered suitable as well (Muir et al. 1982).

There are several ways humans may encounter Fluridone during or after the treatment period, including drinking water, swimming, and consuming fish from the lake. Nevertheless, no adverse human health impacts have occurred from exposure to Fluridone. With Fluridone being safe for humans, fish, and other plant life within Lake Atitlán, the concerns to consider now are the cost and implementation of this herbicide.

Spritflo, a company that focuses on lake restoration, sells Fluridone at relatively low prices. Despite this, covering Lake Atitlán's surface area would be expensive. For example, one gallon of Spritflo's Fluridone concentration, which covers about 16 acres of surface area, costs USD 1,555 (Spritflo® 2021). Therefore, I propose targeting areas of the lake with the highest concentrations of Hydrilla. Although the cost of implementation is necessary, another concern to consider is community feedback from local indigenous residents.

Farmers and locals who have been growing food and produce all their lives will feel threatened if outside foreigners start meddling with their farms and lakes. Ergo, cooperation with local indigenous residents is necessary to ensure success. Working with the Guatemalan government and guaranteeing that residents know about our mission to save Lake Atitlan is necessary. Educating farmers about Fluridone, how it works, and how we'll implement it into Lake Atitlan will provide trust between both parties. Nevertheless, nutritious runoff and sewage will still fuel the new growth of Hydrilla, so eradicating them should be considered.

Using phosphorus-free fertilizers and detergents to limit nutrient-rich runoff is a more permanent solution that addresses the root cause of eutrophication. Although exchanging synthetic with phosphorus-free fertilizers seems relatively simple, this method still has many problems. Most Mayan farmers adopted synthetic fertilizers to increase their harvest yields and became more independent from the government-regulated labor market (Carey 2009). Because farmers are currently dependent on locally-sourced synthetic fertilizers, this creates strife with supply and demand. Introducing a new, competitive phosphorus-free fertilizer incentivizes farmers to transition, which causes companies that sell synthetic fertilizers to lose business. Therefore, working with economists in the region will help assess the cost-benefit analysis of this new fertilizer. Another consideration, phosphorus-free fertilizer is currently less expensive than synthetic, which could alleviate price issues for farmers in the short run.

Removing the nutrition that helps spread Hydrilla would eradicate it from Lake Atitlán, but it might also leave plants and crops with a phosphorus deficiency. Nevertheless, readily available phosphorus is less than the total phosphorus in the ground (Prasad 2019). In many cases, farmers do not need to apply more phosphorus to meet crop requirements. Most of the soil near Lake Atitlán has plenty of nutrients already (Matsumoto 2013). Still, it's essential to keep in mind that in some areas of land, phosphorus can bind very quickly with iron, aluminum, manganese, and calcium in the soil (Neher 2021). Therefore, conducting more research analysis in Lake Atitlan's soil is crucial in determining how much phosphorus plants need to grow ideally.

Teaching farmers newer and efficient farming techniques can leave a long-lasting impact on Lake Atitlán. For example, using fertilizer in the proper amount at the right time will significantly reduce the quantity of phosphorus and nitrogen that reaches the lake (EPA 2020). Moreover, conservation drainage practices can help reduce the phosphorus and nitrogen in drainage water while maintaining suitable drainage for crop production. Thus, modifying water level structures within Guatemalan farms will help control the quantity of water that reaches Lake Atitlán. Implementing denitrifying bioreactors near the end of a tile line will remove nitrates from the contaminated drainage water (Purdue). Although bioreactors seem like a great solution, it does come at a price. The overall installation and cost of these machines are about USD 10,000 - 12,000. They do, however, require little to no maintenance and last for up to twenty years. Subsequently, conservation drainage practices reduce nutrient, pathogen, and pesticide loading from

drainage systems into downstream receiving waters, while also improving crop productivity, health, and vitality.

Lake Atitlan's water and sanitation challenges are imminent, and the local population, alongside local and federal governments, are well aware of the situation. Many solutions discussed above could theoretically work. Regardless, finding a source of funding for Lake Atitlan is difficult. For example, the Guatemalan government proposed a solution to remove 100% of the wastewater before it discharged into the lake (Travieso n.d.). Funding was available in 2015 to upgrade existing Wastewater Treatment Plants (WWTP) to solve the wastewater problem. However, clearance and political issues stalled the plan's production (Neher 2021). In another instance, the Guatemalan government proposed a multipart plan to cut all phosphorus from entering the lake after the large cyanobacteria bloom in 2009 (Fieser 2009). This plan called for installing multiple new WWTPs in the basin and switching to organic farming, meaning without pesticides and fertilizers. The plan was to raise 350 million USD, but the funding goals were not met, and the project came to a standstill. One potential option to combat this financial problem includes borrowing money from international agencies, like The World Bank, and implementing a small tax on tourists who visit the lake to pay off future loans.

Using all methods would be the best course of action. Fluridone kills Hydrilla quickly and safely, but at a price. Targeting specific locations on Lake Atitlan is more reasonable. Creating policies that provide restrictions and guidelines for using Fluridone in Lake Atitlan is critical to the safety of residents, wildlife, and plants. Yet, using this method will only provide a short-term solution by killing the Hydrilla currently in the lake. To end the devastating power of Hydrilla in the future, it is vital to eliminate its primary source of intake.

Transitioning from synthetic fertilizers to phosphorus-free fertilizers limits the amount of nutrition Hydrilla receives to grow. However, this transition would lead to a significant economic change within Guatemala's labor market. Businesses that sell synthetic fertilizers would lose money or must transition to phosphorus-free instead. Farmers would not have to pay as much for fertilizer, though, since phosphorus-free is less expensive. In addition, using phosphorus-free should not pose a danger to plant growth since most soil surrounding Lake Atitlán has plenty of phosphorus.

Advanced techniques such as conservation drainage practices convert nitrogen and phosphorus into nitrate gas through denitrifying bioreactors. Nitrate gas is used to help produce proteins in plants for healthy growth. These machines account for 100 acres of land, require almost little to no maintenance, and last upwards of 20 years if used properly. This proposed solution does come at a price, though, so it is essential to consider the cost-benefit of these devices in specific locations surrounding Lake Atitlan.

Eradicating Hydrilla from Lake Atitlán will help remove toxins and provide much cleaner water for the 400,000 indigenous residents that benefit from it. In addition, the child mortality rate will expectedly drop if Lake Atitlan is saved successfully. Finally, the statistic about 95% of Guatemala's drinking water being impure will no longer be a reality. Tap water would soon be a safe drink again. Children and adults will no longer worry about diarrhea and cholera conditions by drinking the water in Guatemala. In tackling this issue of water sanitation, residents who have historically been overlooked and left unassisted will finally receive the help they need to have prosperous and healthy lives.

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