Green Movement Against Green Water

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ABSTRACT:

How do you start a green movement in a country where people have no interest in knowing where their water ends up at the end of the pipe? Why would people in Guatemala want to put a septic tank on their property knowing that their neighbors upstream will be dumping their sewage directly into the river?
This thesis probes strategies that promote a symbiotic relationship between human development and ecological regeneration and management practices that support resilience. This research characterizes the watershed of lake Amatitlan in Guatemala, looks at the contaminants and issues affecting it, evaluates remediation strategies currently being used and suggests alternative strategies based on ecological restoration design. These strategies were inspired by case studies of various modern practices used for filtration, remediation, management and environmental education. Additionally, the design of a reconstructed wetland near the lake will demonstrate how natural processes can be used to filter polluted effluents and provide habitat for underrepresented fauna and flora. This proposed wetland will become a park that provides an educational and aesthetically pleasing environment where people can enjoy nature and take part in an emerging green movement in Guatemala.

Key words: Guatemala City, Watershed, Lake Amatitlan, Ecological Restoration, Environmental education, Constructed Wetland.

1.0 INTRODUCTION TO THE LAKE AMATITLAN WATERSHED AND EXISTING PROBLEM

The most polluted lake in Central America is Amatitlan Lake, a eutrophic body of water in Guatemala that receives its effluents from a largely urbanized watershed with an area of 381 Km^2. With more than half of Guatemala City situated within the lake's watershed, polluted runoff and sewage from the rivers constantly get deposited into the lake with a surface area of $15km^2$, turning it into a dead, eutrophic body of water with contamination ratings comparable to a sewage tank. With 3 million inhabitants, the watershed is composed of housing developments, illegal settlements, sprawling communities, agricultural farms, and 30% of the country's total industry. Most people living in this watershed don't imagine that the untreated domestic waste that they dump into the rivers is partly to blame for the catastrophic degradation of Lake Amatitlan. This degradation forbids the use of this lake as a potable source of water, which is especially unfortunate because, according to the US Army Corps of Engineers, "the scarce surface

water resources of Guatemala City cannot support the requirements of its population. Consequently, ground water resources are required to supplement the needs of the city. However, many shallow aquifers are contaminated" (US Army Corps of Engineers, 2000 pg.3). It is therefore indispensable for the Guatemalan people to take action and begin taking part in a green movement that will prevent the eutrophication of Lake Amatitlan.

2.0 HIGHLY ENGINEERED GOVERNMENT REMEDIATION STRATEGIES

Its strategic location close to Guatemala City has allowed a government organization, the Administration for the Sustainable Management of Lake Amatitlan and its Watershed (AMSA), to build several remediation projects that will serve as models for the management of other lakes throughout Central America and even the world. Water contamination has always been an important topic in developing countries like Guatemala, but rarely one sees a real movement against contaminated water such as the one being led by this organization. However, AMSA's "end of pipe solutions" have been addressing issues at the end of the river and within the lake, rather than focusing on the significant causes and sources of problems. Additionally, recognition of AMSA's efforts is lacking. People continue using water irresponsibly, and legislation has not been enforced.

One of AMSA's filtration projects includes the water treatment ponds that divert water from the Villalobos River and put it though a system that helps filter the water before heading into the lake. In order to treat the heavily polluted 437.5 million daily liters of water discharge coming from the Villalobos river, AMSA has built three macro-treatment plants within the watershed. Of these plants, only the largest one is currently operating, and has a tri-partite system of primary, secondary and tertiary treatment designed to treat different concentrations of pollutants in water. At the end of the system, a structural sedimentation pond on the river's former delta was built to receive some of the water and allow the sediments to settle. These sediments are continuously being dredged out of the pond.

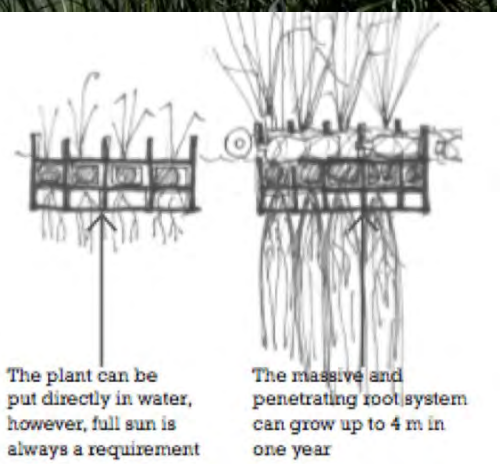
Biologists, chemists, and aquaculturalitsts have been hired to monitor the health of the lake. Many of them, while very enthusiastic, were disappointed with how their efforts were thwarted by the inability to address contaminats at the source. It is difficult to say with certainty whether these attenuation projects have actually managed to reduce the contamination of the lake, especially because graphs of the Villalobos River showed a disencouraging increase in the chemical oxygen demands (the mass of oxygen consumed by bacteria per liter of solution) rasing from 40 mg/L in 2005, to 98 mg/L in 2007. This means that in 2007 there was more microcystin bacteria infesting the surface of the lake than in 2005.

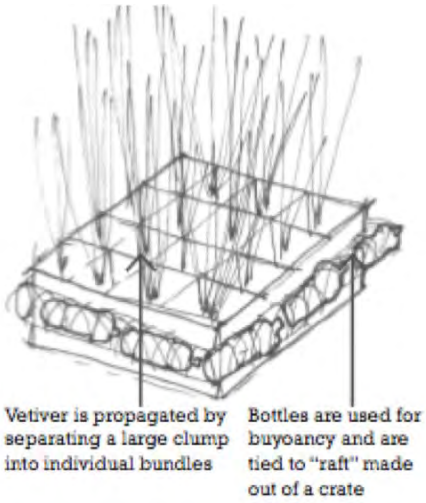
3.0 DESIGN STRATEGIES FOR A RESILIENT, ADAPTABLE AND PROGRESSIVE CITY

To overcome the above problems, this thesis proposed a broad scale watershed management approach that combines strategies from the Vetiver System with other Green Infrastructure practices that could be implemented in the Guatemala City Watershed. A significant component of this research proposal involved studying the Vetiver System which uses the plant C*hrysopogon zizanioides* for various kinds of green infrastructure projects throughout the world.

The author first encountered green infrastructure using Vetiver in a monastery on the hills of Lake Amatitlan, were the nuns were using it to filter the dirty water in tilapia fish tanks. The fish tanks, which were built in the form of terraces, had Vetiver Rafts ingeniously made out of completely recycled materials – plastic soda bottles and Coca Cola crates (see diagram below). Additionally, the nuns used the Vetiver to stabilize their steep slopes and the roots to make incense for mass.

Similar structures have been used successfully in Australia and Asia to treat contaminated water and effluent:





Sewage effluent pond *Pig farm effluent ponds in China and Vietnam in Australia*
Source: The Vetiver Network International

Some of the strategies that should be implemented in the Guatemala City watershed include:

3.1 STRATEGY 1: REDUCING RUNOFF USING BEST MANAGEMENT PRACTICES

Establish a strong communication between the Guatemala City zoning board and Guatemala's Department of Environmental Conservation, so that key forest corridors, river systems and habitats are identified and preserved. These ecosystems exist beyond a single property's boundaries, and for this reason there is a need for overall entity that can identify where these corridors are, how the hydrology of the region should work, and the locations of suitable sites for development within the property. In order to achieve a zoning plan that truly reduces environmental impact, runoff needs to be controlled throughout the watershed using best management practices. Minimize runoff in parking lots and large impermeable surfaces need by using permeable paving materials, building swales, rain gardens, roof gardens or detention ponds planted with a mix of Vetiver and native plants. These practices prevent erosion caused by runoff and allow water to infiltrate the ground and replenish the watertable. They also filter the heavy metals and contaminants usually found in parking lots and prevent them from being flushed away into the rivers. This significant reduction of pollutants and sediments in the water would help speed up the regeneration of healthy water in Lake Amatitlan

3.2 STRATEGY 2: PROTECT EXISTING FORESTS AND RESTORE RIPARIAN ZONES

Within the city, there are beautiful, healthy forests that have not yet been obliterated thanks to steep, precarious dendritic gullies that they inhabit, which are inhospitable to human development. On the other hand, there are less fortunate riparian zones and river edges that people have taken the liberty to occupy, knowing that there is a chance that their houses will be washed away in the event of a hurricane or large storm.
In response to these concerns, the following are some recommendations both for the zoning board and for the city as a whole:

1. Protect the remaining forests that exist throughout the city and the watershed, especially those that are near rivers and have been identified as important habitat corridors for local wildlife.
2. Protect the river's edges and riparian zones which are known to be flooded, and create disinincentives for people living close to these rivers (like flood insurance and impact compensation duties)
3. Restore riparian zones which have been eroded by the increasing flow of water. Use vegetated "Geo-grids" to reduce erosion, reshape banks using Vetiver System methods as methods proposed by the Federal Interagency Stream Restoration Working Group (link)
4. Wherever possible, daylight streams that have been diverted into pipes.
5. Restore river channels to their original winding shape.

3.3 STRATEGY 3: CONSTRUCTED WETLAND PARK IN LAKE AMATITLAN: "VETIPARQUE"

The mouth of Rio Villalobos originally had the shape of an alluvial fan delta which was covered by newly deposited sediments, colonizing plants and emerging trees that tolerated saturated soils. This sector was then redesigned by AMSA and converted into a sedimentation basin with a rigid, trapezoidal shape which was meant to catch and treat 172,800 m^3 of water coming from the Villalobos river. Although this structure has become an emblem of the progress for AMSA, the pond is quickly being filled up by sediments and it is not as effective in cleaning up the water coming from the Villalobos River. Additionally, the pond emits strong putrefying odors, and it is not open to the public. As a matter of fact, none of the filtration plants that AMSA has built are accessible to the public without permission from AMSA's headquarters.

Interestingly enough, the location where this river delta was situated actually belongs to the nuns living in the monastery across the lake who have been monitoring the efforts of AMSA from their residence. They gave this government agency permission to construct this "solid waste retention lagoon" which sounded very promising and was going to significantly reduce the pollution of Lake Amatitlan. More recently however, the Monastery has been complaining about the smells the putrefying sediments emitted from the stagnant waters in the pond and have not really seen a significant change in the quality of the lake's water. They are also disappointed about the hundreds of trees that were cut down in order to have this structure built.

The idea of a constructed wetland park where people could come learn about water filtration, best management practices, responsible habits and green infrastructure, sounded like an attractive idea to them. In addition to filtering water and providing a habitat for wetland species that have been constantly driven out, such a wetland would be a great place for the children from the orphanage operated by the Monastery to learn about becoming stewards of the environment and leaders in an environmental movement operated by people who are genuinely interested in restoring the city's ability to co-inhabit with nature.

3.4 **DESIGN INTENT FOR THE VETIPARK**

There area three main design goals for this constructed wetland:

- To aid in cleaning the effluents from the river and reduce lake eutrophication
- To educate people about sustainable practices and ecology
- To attract Wildlife and increase biodiversity

Some of the Specific design strategies used for the "Vetipark" include:

- Design using local plants (Nympha, Typha) as well as introduced species with a known functionality, such as Vetiver.
- Incorporate the sedimentaion pond and the water treatment plant that has already been constructed by AMSA, but make them open to the public and replace some of the plants that they use with Vetiver grass.
- Implement interactive educational programs within the park which through education boards exposes them to vocabulary such as watershed, phosphorous, nitrogen, microsystin, erosion, riparian zones, habitat corridors, best management practices, and other green infrastructure possibilities. High illiteracy rate in Guatemala makes it crucial for boards to be visually powerful and explain these strategies through diagrams, pictures and drawings.
- Host workshops for recycling and sorting waste, reestablishing wildlife habitats,

creating affordable water filtration and detention practices

- Encourage participation from communities throughout the watershed when constructing this wetland. Have a good marketing campaign that will make people want to contribute to the green movement against green water. This campaign will help Guatemalans take pride in our abundant natural resources and beauty, and begin looking at them as an amenity that can attract local and international tourism and development.

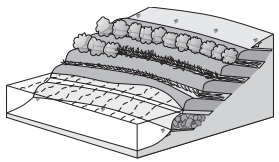
3.3 FUNCTIONALITY OF THE VETIPARK :

Water from the Villalobos river is diverted into this constructed wetland (see diagram on next page) whose water holding volume is about the same as the wastewater treatment ponds and biofilters that AMSA constructed a bit further upstream, meaning that it would very likely also treat about 1/3 of the river's discharge in the dry season. However, it is very likely that this system will be much more efficient at removing the excessive amounts of nutrients and pollutants coming from the river as it filters water through specialized soil media and vegetative wetland species that have adapted to harsh conditions (and also require much less maintenance). Water first gets diverted into a matrix of Vetiver planted beds which allow the water to flow through them, getting filtered by the roots of the plants, or also flowing above the beds through weirs. Water then flows at a faster rate through a grouping of islands that help aerate the water though channels intersecting with one another. The edges of these islands are planted with local typha to reduce erosion and filter the water. The large trees that are planted in these islands are Amate Trees, an enormous, slow growth species that is native to Lake Amatitlan. Some of the water could then flow into the nearby bay or it can keep flowing though a winding river, which has Vetiver planted at an area that can be flooded and become a pool of filtered water. Finally, the water is diverted to the existing mouth of the river (which has been expanding through sediment deposits). This area will be planted with tightly planted rows of vetiver, which would eventually form terraces that prevent the sediments from further filling in the lake. The goal is for this wetland to become a cherished eco-tourism park for Guatemalan people, filled with boardwalks, kiosks, educational boards, camping grounds, birdwatching centers and a place where people can learn about the importance of treating their watershed with respect and enjoying the diversity of wetland species.

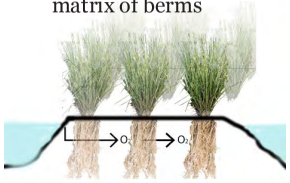
Vetipark

Amatitlan Lake, Guatemala

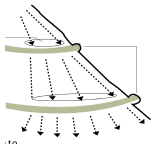
1 Riparian riparian restoration using " Vegetated Geo-Grids"



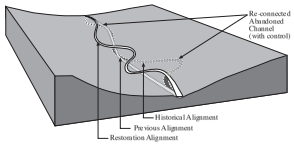
2 Vetiver Berms water gets filtered as it permeates through this matrix of berms



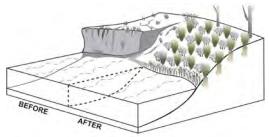
3 Vetiver Stabilization: Erosion of steel hills prevented with Vetiver plantings



4 Original flow: Restore the original sinuosity of the river



5 Reconstruct eroded river edges: sloped ground will reduce instability



6 Vetiver Terraces: Roots of plant naturally build up terraces when planted in strips

7 Modular Wetlands: Raft planted with Vetiver built with Recycled materials

SOURCES

Calderon, I Maria. Green Movement Against Green Water. Cornell University. Ithaca: May 2010

Figueroa, Gerardo. Revista Realidad, Construyendo unidos un mejor pais: AMSA. Guatemala: 2005. 1-31

Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG). online

Truong, Paul, Tran Tan Van, and Elise Pinners. Vetiver System Applications - A Technical Manual. Second Edition: 2006

US Army Corps of Engineers Mobile District & Topographic Engineering Center. Water Resources Assessment of Guatemala. United States Southern Command: June 2000