SUSTAINABLE AGRICULTURE IN THE WETLANDS OF MEXICO CITY

2015
FIELD
REPORT

EARTHWATCH INSTITUTE

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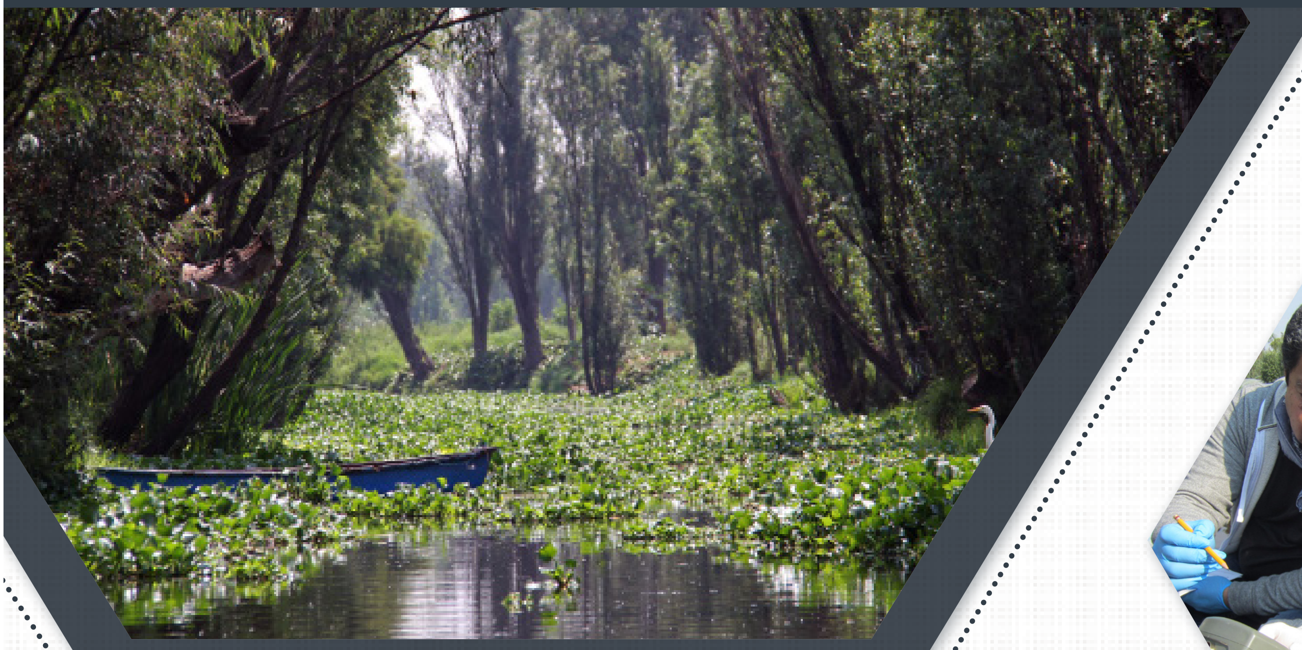

Dear EY Participants:

It was a pleasure to meet you all! EY 2015 Americas Ambassador Program was a wonderful experience for producers, for NGO REDES, as well as for National University professors. This season we worked at two contrasting sites, Xochimilco lake and San Gregorio canals. It was a revealing experience to know the chinampas and farmers of San Gregorio. They were deeply touched by the opportunity to meet the EY team and they really appreciated your contributions. Today, there are three farmers with brochures and business cards. Not only that, there is interest in forming an organized group to sell their greens under the name of “Sabor Chinampa.”

Our main goal is to develop strategies that enable the farmers to do eco-friendly agriculture as a formal business. In order to achieve this, we aim to have an integrated vision of the problem and proposed solutions. We have been working with them on solutions such as agroecological training, opening of selling points, improvement of water quality for irrigation, and biodiversity conservation. But the support received by EY through its volunteers in terms of management, marketing, problem solving, production control, and social networking, have contributed to increasing farmer´s skills more broadly,.

For the research, it was incredibly helpful to have your support given the extension and number of sites monitored. Results of the monitoring have helped us to better understand the behavior of the different variables in both systems and it was a big surprise to find four Axolotls at San Gregorio canals during the monitoring in 2015! As you know, the environmental situation of San Gregorio is much more critical, and yet these extraordinary amphibians have somehow managed to survive.

Next year we expect to improve the research at San Gregorio and we are working to offer new experiences and challenges for the next EY teams.

Thank you so much for your enthusiasm, contributions, and empathy.

Sincerely,

Elsa Valiente

Sustainable Agriculture in the Wetlands of Mexico City

2015 FIELD REPORT

Background Information

LEAD PI: Elsa Valiente

REPORT COMPLETED BY (NAME): Elsa Valiente, Jannice Alvarado

PERIOD COVERED BY THIS REPORT: 2014-2015

CHANGES TO:

PROJECT LOCATION:

The research location was extended to San Gregorio Atlapulco, Xochimilco, which is also part of Xochimilco wetland. While Xochimilco Lake is a continuous broad canal system, San Gregorio has evolved in a fragmented canal system with a slope from urban to wetland area. In the middle, several grades of intensive agriculture could determine different water quality along transects.

Both systems share some anthropogenic impacts in different degree: residual water as the main income, domestic waste water income along urban edge, leakage of pesticides and inorganic fertilizers, subsidence and introduced species.

Same parameters and methodology was applied to both systems in order to understand the behavior of nutrients (NO_3 and PO_4), heavy metals, ammonia, fecal coliforms, main limnologic parameters and the modified biotic families index (MBFI). Grease, oil and detergents were also determined for some sampling points.

PROJECT SCIENTISTS:

PhD Claudia ponce de León
PhD Leopoldo Galicia
Biol. Jannice Avarado

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SECTION ONE: Scientific research achievements

TOP HIGHLIGHT FROM THE PAST SEASON

The understanding of the historical evolution of the Xochimilco wetlands; how two communities next to each other have managed the same original system in such different ways and how it has resulted in terms of sustainability.

REPORTING AGAINST RESEARCH OBJECTIVES

Objective 1. Compare agro-ecosystem chinampa vs technified chinampa through the scientific research on biodiversity and water quality to increase local awareness and improve ecosystem health.

This report shows the results for 2014-2015 study periods. In total 59 samples for Xochimilco and 46 for San Gregorio were analyzed as a first approach exploratory study. Fig 1 shows the location of sampling points.

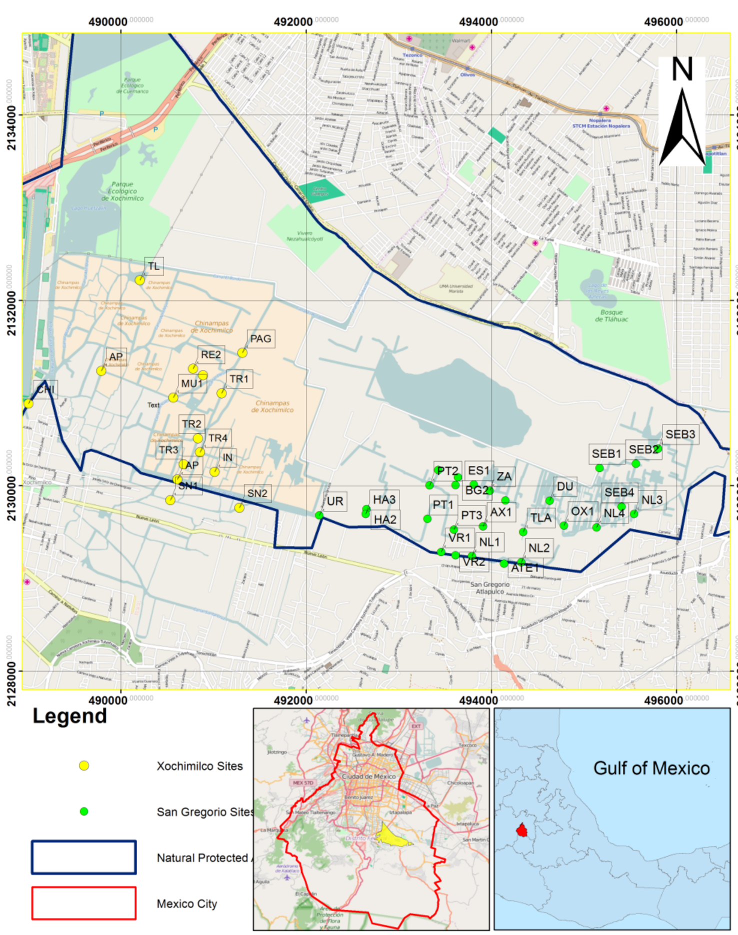

Fig.1. Map showing the study area Xochimilco (left side), San Gregorio (right side) and the sampling points.

Sampling was done for dry (April-May) and rainy season (September-October). We had the support of EY team to sample the stations during May and for April and September-October sampling we had the participation of local farmers guided by REDES research team. Given the nature of the sampling locations, at Xochimilco we did the collection and processing of samples with EY team on a boat and for San Gregorio locations we walked along transects from urban to wetland area with EY team and local farmers to collect the samples. The samples processing was made *in situ* at facilities provided by the farmers.

In order to accomplish quality assurance and quality control in collection and processing of the samples, each team was guided by one expert of the REDES research team who made first a demonstration and then supervised the collection and processing of samples.

A main purpose of the study is to facilitate the understanding of concepts such as eutrophication, organic pollution, pathogens, indicators, etc. through a living experience with immediate exploratory results that help to identify major issues in water quality.

Results

Statistical analysis was performed with R version 3.2.1 package and variables measured were: Nutrients (NO_3, PO_4 and NH_4); DO (mg/L), Temp °C, pH, Conductivity (µS/cm), TDS (mg/L), Turbidity (NTU); fecal coliforms and E. coli; heavy metals (Cd, Cr, Pb and Cu); grease, oil, soap and the modified biotic family index MBFI. Number of samples for San Gregorio was 59 and for Xochimilco 46.

Physico-chemical parameters:

Temperature

This variable is most important for the endemic amphibian *Ambystoma mexicanum* and for other native aquatic organisms such as the crayfish *Cambarellus montezumae*. Both are organisms who like low temperatures.

Also having low temperatures in water is helpful to prevent undesired chemical process. The following graph shows that San Gregorio has a median of 2°C lower than at Xochimilco. This condition might be influenced for the fact that at San Gregorio canals are narrower and receive coverage from the trees.

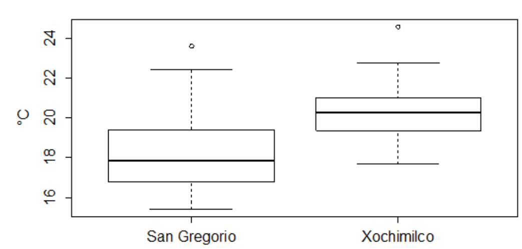

Figure 2. Temperature (°C) at San Gregorio and Xochimilco wetlands for 2015

pH

For this parameter results show no significate difference among both systems. Median is between 7 and 8, however there are some outliers with more basic measurements at both systems and an acidic site located at the point where water from Xochimilco system exit to the sewer system of Mexico City. Before getting to Canal Nacional, the exit to the wastewater pipe, the water passes through a 1 km canal full of water hyacinth (*Eichornia crassipes*) and the high decomposition rate of this area result in a pH of 3.

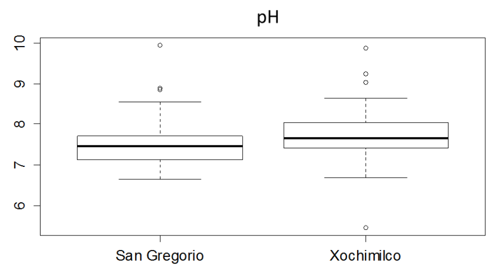

Figure 3. pH at San Gregorio and Xochimilco wetlands for 2015

Dissolved Oxygen (%)

San Gregorio shows anoxic conditions during all the year, dissolved oxygen levels at San Gregorio reflect a high chemical and biological demand for this gas which is due to the constant and high rates of organic matter produced by the agriculture in this area.

In contrast, Xochimilco present a median of 50% along the year which is also a low concentration for aquatic organisms. Wider canals and a lower density of cropland might help to increase the saturation level of oxygen, nevertheless in both systems, some measurements indicate oversaturation, because of high productivity which is a constant in all the wetland.

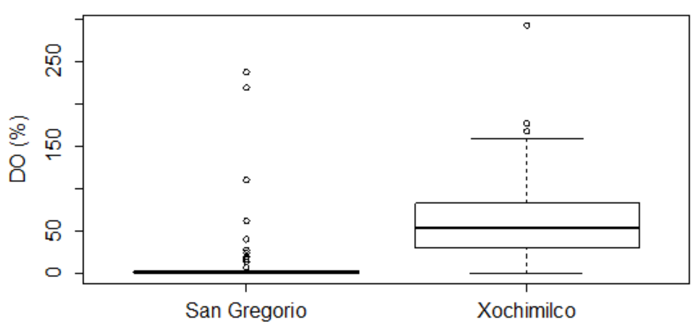

Figure 4. Saturation Dissolve Oxygen (%) at San Gregorio and Xochimilco wetlands for 2015

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Total Dissolved Solids (TDS mg/L) and Conductivity (mg/L)

Conductivity is the measurement of the salts contained in water and these salts are contained in dissolved solids. Electrical conductivity of water also depends on the water temperature, increasing 2-3% with 1 °C.

As seen in graphics, San Gregorio (SG) registers higher values and variability in both parameters, conductivity and total dissolved solids, than Xochimilco. One main reason could be the intensive use of inorganic compounds in SG compared to Xochimilco.

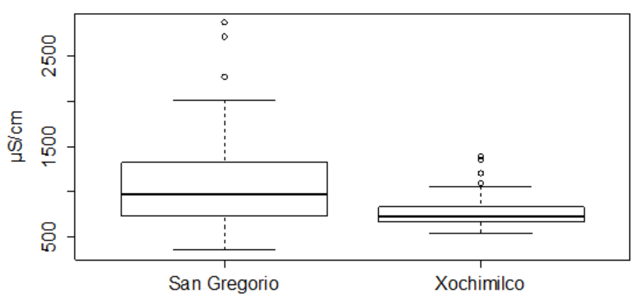

Figure 5. Conductivity (µS/cm) at San Gregorio and Xochimilco wetlands for 2015

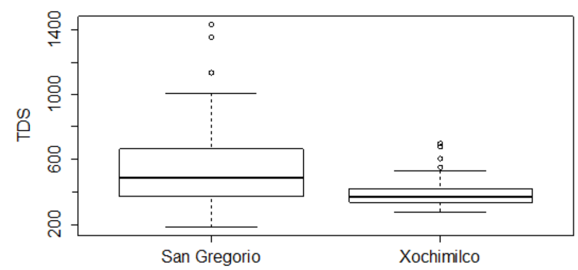

Figure 6. Total Dissolved Solids (ppm) at San Gregorio and Xochimilco wetlands for 2015

Turbidity (NTU)

This parameter reflects the content of suspended material in water and is measured according to the refraction of light in suspended particles in the water. As observed in graphic, SG presents more variation and a lower median than Xochimilco (Xochi). This behavior could be the result of the anthropogenic impact in canals nearest to urban area compared with canals next to the wetland and with fewer crops.

In Xochimilco, canals are more homogeneous in width and depth so there is small variation but the use of canoas and long rows for transportation of tourists and greens is intensive and it produce the re suspension of sediments.

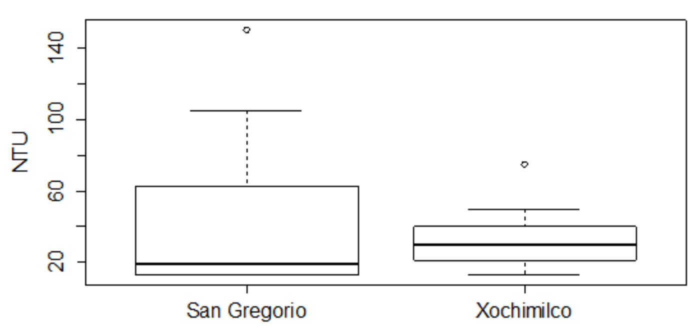

Figure 7. Turbidity (NTU) at San Gregorio and Xochimilco wetlands for 2015

Heavy Metals

In this study Cadmium, Lead, Copper and Chromium were measured with a colorimetric analysis *in situ*, using the LaMotte Smart3 colorimeter.

Results indicate a concentration of Cadmium of 0.0mg/L, with an outlier of 0.12 mg/L from the water treatment plant pipe at Xochimilco Lake, which exceeds the maximum limit allowed by Mexican normativity for irrigation water (0.2 mg/L) (NOM-001-ECOL-SEMARNAT) and should be monitored. For Chromium the limit is 0.5 mg/L but the results indicate a median below the detection limits in both systems. The lead showed a median concentration of .07 mg/l for SG and 0.04 mg/L for Xochimilco, both being below the limit for wetlands (0.2 mg/L) and for crop irrigation (0.5 mg/L). For Copper at SG median value was 0.1 mg/L and for Xochimilco 0.015 mg/L both values are below the limit allowed by NOM-001-ECOL-SEMARNAT, which establish 4 mg/L for crop irrigation and wetlands.

For all heavy metals SG showed higher variability but this might be due to the higher content of suspended organic matter (turbidity) or TDS.

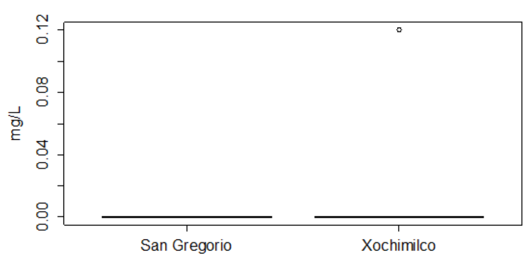

Figure 8. Cadmium (mg/L) at San Gregorio and Xochimilco wetlands for 2015

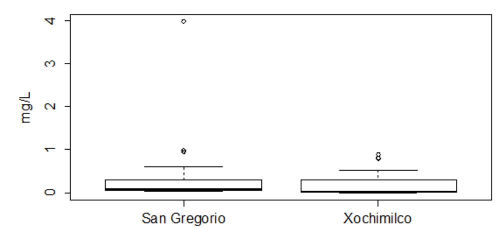

Figure 9. Lead (mg/L) at San Gregorio and Xochimilco wetlands for 2015

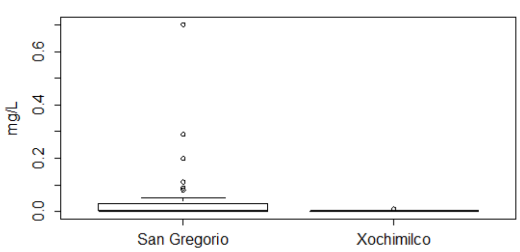

Figure 10. Chromium (mg/L) at San Gregorio and Xochimilco wetlands for 2015.

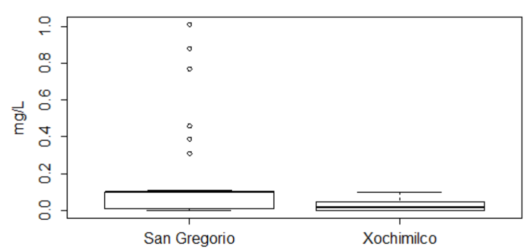

Figure 11. Copper (mg/L) at San Gregorio and Xochimilco wetlands for 2015

Bacteria

The presence of bacteria coliform group (total coliforms and Escherichia coli) is an indicator that there is stool suspended in water, it is also indicative of the presence of other harmful bacteria causing diarrhea and severe gastroenteritis. The maximum value allowed for irrigation water with direct contact with water is 1000 UFC / 100 ml (NOM- ECOL-003). In Mexican regulation there is not normativity for E.coli specifically.

Results indicate total coliforms concentrations much higher than the limit in both systems. SG shows higher concentrations, however it didn't show a significate difference with Xochimilco.

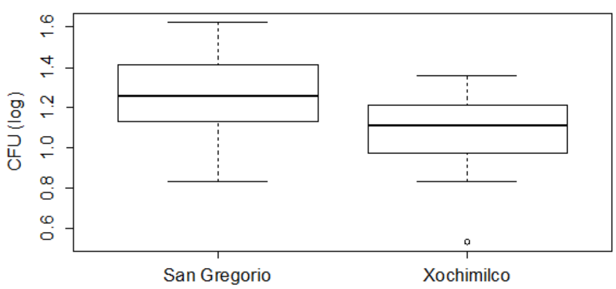

Figure 12. Total Coliforms (log) at San Gregorio and Xochimilco wetlands for 2015.

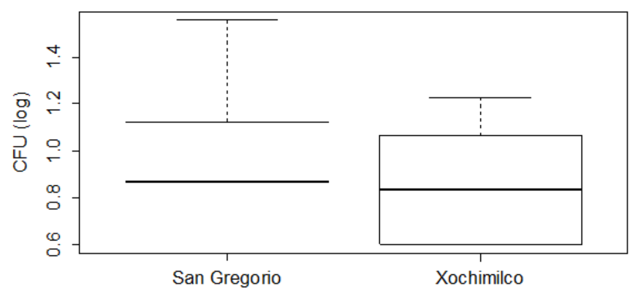

Figure 13. *Escherichia coli* (log) at San Gregorio and Xochimilco wetlands for 2105

Nutrients

Nitrates and phosphates are the main nutrients for plants in aquatic systems. An excess of nutrients in water result in the eutrophication of water bodies and in some cases concentrations become toxic for aquatic organisms and for human health. Nitrogen cycle is very dynamic and depends on water temperature and dissolved oxygen, the nitrogen from the atmosphere is converted into nitrates, nitrites and ammonia.

In this study nutrients were measured with Earthwatch water kit and for ammonia the samples were preserved and taken to the laboratory.

Results show there is not significate differences in both systems for Nitrates, Phosphates and Ammonia, nevertheless San Gregorio shows more variation throughout the year.

In Mexican normativity these nutrients are regulated as total phosphorus and total nitrates, however the fraction available to aquatic vegetation are those with ions exchangeable. For international regulations, unpolluted surface water contains values among 0 and 5 mg/L. According to this standard the values obtained are under the maximum limit. Nevertheless, in water nitrogen molecule is transformed into NH_3/NH_4 – NO_2 –NO_3. The unionized form of ammonia is more toxic than the ionized one but its concentration depends on water pH and temperature. In alkaline water NH_3 is the dominant form, which is harmful aquatic organisms and very toxic to amphibians. Appropriate level of ammonium is <0.2 mg/L.

In spite of the intensive use of inorganic fertilizers, NO_3 shows low concentrations, 0.35 for San Gregorio and 0.75 for Xochimilco. However NH_3/NH_4 concentrations, especially in Xochimilco, approach to toxic levels. Oxygen concentration, temperature and pH are parameters that might be influencing the concentrations of the different forms of nitrogen; therefore, further research is required in order to understand the nitrogen cycle at Xochimilco and San Gregorio wetlands

Something to be considered is that NH_4 and NO_3 are soluble and easily transported to aquifers through underground especially in rainy periods. Study of nitrogen in sediments could help to understand if this element is being retained, how much and the risk potential of aquifer pollution.

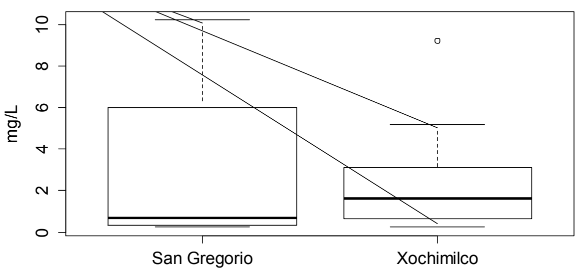

Figure 14. Ammonium (mg/L) at San Gregorio and Xochimilco wetlands for 2015

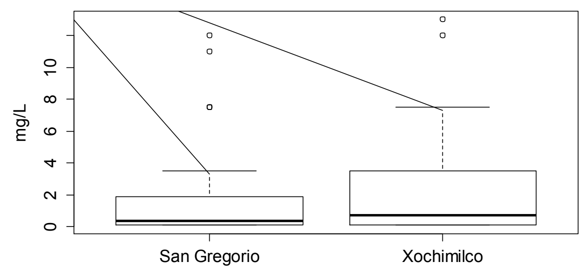

Figure 15. Nitrates (mg/L) at San Gregorio and Xochimilco wetlands for 2015

Phosphates

High concentration of this element has immediate impact on water quality. One gram of phosphates (PO4-P) produces the growth of 100 g of algae. to start the eutrophication process critical concentrations of PO4-P are for running water 0.1 - 0.2 mg/L, and in water bodies with low flow, 0.005 – 0.01 mg/L.

Results for Xochimilco and San Gregorio with low flow of water are 1.2 mg/L, therefore we can say that all the wetland is eutrophicated.

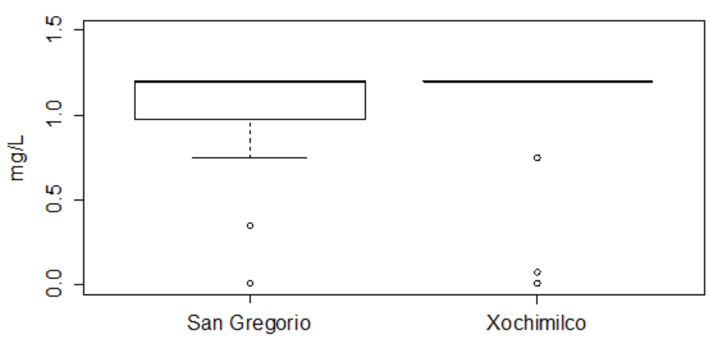

Figure 16. Phosphates (mg/L) at San Gregorio and Xochimilco wetlands for 2015

Fats, oils and detergents

According to Mexican normativity (NOM- ECOL-003-SEMARNAT), the maximum limit for waste water of fats and oils is 15mg/l and for detergents is 10 mg/L

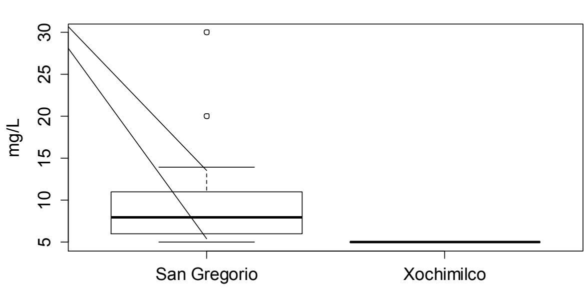

Figure 17. Fats and Oils (mg/L) at San Gregorio and Xochimilco wetlands. 2015

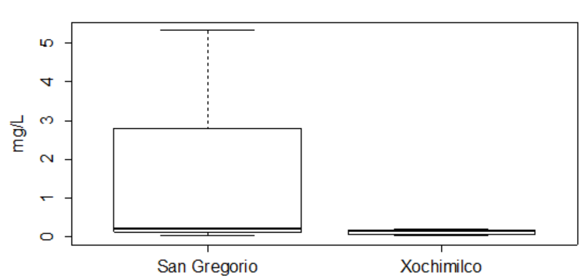

Figure 18. Detergents (mg/L) at San Gregorio and Xochimilco wetlands. 2015

Modified Biotic Index

In order to obtain the level of organic pollution at the different areas of the wetland, we used the Modified Families Biotic Index (IBFM), the Macroinvertebrates tolerance values (Mandaville 2002), and the existing information on Xochimilco macroinvertebrates (Merlo-Galeazzi, 2014). Macroinvertebrate sampling was done at the same points as for physicochemical sampling, applying 10 times netting effort with sweep nets under floating aquatic vegetation and at the walls of the land plots, dragging from the roots of aquatic vegetation up to the surface. Sweep nets used were triangle type with a mesh size of 500 µm. We cleaned up the collected invertebrates of any unwanted material, then fixed with 70% ethylalcohol and identified to family level. Macroinvertebrates were grouped into functional groups, in order to have another element for discrimination.

The MBI was similar for both systems, Xochimilco and San Gregorio. During dry season all sites are classified in the Very significant organic pollution and during rainy season Xochimilco sampling sites became in the severe organic pollution classification. This mean that most of the families of macroinvertebrates found in the study area are very tolerant to organic pollution.

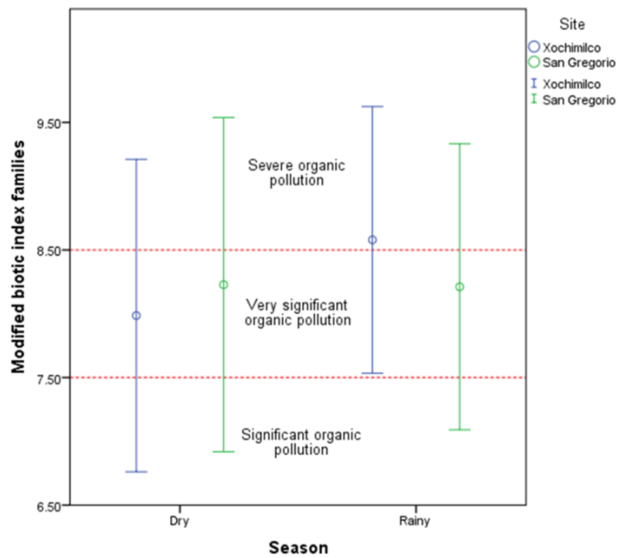

Figure 19. Modified Biotic Family Index at San Gregorio and Xochimilco wetlands. 2015

Between Xochimilco and San Gregorio systems the parameters showing significant differences were dissolved oxygen, conductivity, fat, oil and detergents. San Gregorio canals showed the lowest values for dissolved oxygen and the highest values for conductivity, fat, oil and detergents. Therefore the impact of anthropogenic activities is more evident in SG than in Xochimilco, but basically both systems are eutrophicated and fecal coliform bacteria represent a health risk. The impact of organic waste discharge directly into the canals and the practice of improper disposal is evident and constitutes an urgent matter of water management in the area.

Building of dry toilets in the chinampas (crop land plots), recovering the waste water to the municipal collector or having filtration systems in the edge of the urban area are some actions that should improve water quality.

Phosphates input would decrease with domestic waste water filtration and also very important, with a significant decrease of inorganic fertilizers in agriculture.

High rates of organic matter decomposition result in anoxic conditions which prevent the survival of native aquatic species and favor the survival of introduced species such as tilapia (*Oreochromis niloticus*) and carp (*Cyprinus carpio*).

Heavy metals are a potential risk to human health but basic pH values in water prevent the heavy metals from becoming available for plants. Sampling was also done at the entrance of water coming from the waste water treatment plan and results showed high concentrations of cadmium. Therefore the process at the waste water treatment plant, which provides water to the whole lacustrine system, should be reviewed by authorities.

In the case of nitrates also the highest concentrations were recorded in the water coming from the waste water treatment plant.

Objective 2. Demonstrate to local producers and authorities that doing environment-friendly agricultural practices, will enhance both market values of local production and the improvement of the wetland health.

Objective 3. Economic assessment of the benefits and costs, both private (i.e. market values) and environmental (i.e. non-market values) of sustainable agriculture carried out by local producers in Xochimilco, Mexico.

The proposals done to farmers from the EY teams were very helpful and induced action especially with farmers from San Gregorio. We continued working with them during 2015 and now they are working to sell their greens as a group. Three of them have already their business card and brochures and during 2016 the goal is to have communication tools between the group in order to know which and how much crops they have, to identify clients and promote the products as a group.

They also need a financial plan to transition from a production based in agrochemicals to an agroecological management. It is basic for them to assure their income and diminish the losses, therefore a financial scheme by stages would be very helpful. Management of loans or credits is also an unknown matter for them. There are experiences around the world to empower communities through the microcredits. We think that building a proposal for organizations such as Kolping International could be very helpful.

SECTION TWO: Impacts

PARTERNSHIPS

US Fish & Wildlife Agency has been an active supporter of our activities. During 2015 and to be finished on May 2016, we have carried out a project on sustainability of 12 farmers, most of them took part in 2015 EY Ambassador Program. During USFW project we have worked with them in the training of water quality monitoring, administrative tools and the evaluation of the crop activity of each one in terms of sustainability.

CONTRIBUTIONS TO POLICIES OR MANAGEMENT PLANS

Our NGO has been conducting as a self-supported project, the recovery of one land plot (chinampa) since three years ago with organic manure and since last year with agroecological planning. Also we have rehabilitated a narrow canal for native species survival, such as the axolotl, *Ambystoma mexicanum*. This apantle has proved to be a good reservoir for native species because we have found godeids, crawfish, collectors as well as predator macroinvertebrates, and also water snakes which are main predators for axolotl and the reason why we can't have axolotls free but need to be in cages in order to survive to adult stages. Also introduced species have been found, such as Xenobus, an African frog, the first record of this amphibian at Xochimilco. Another self-sustained project we have been conducting since two years ago is opening friendly markets for local producers. We produce and gather greens from other producers already trained in agroecological production and sell packages of greens to directly consumers. Producers get the double of the price in local market and REDES get the economic resources to continue with maintenance of the land plot. However this is an activity which is not sustainable yet, since the payment to workers has been financed by a third person.

CONSERVATION OF TAXA

We have collected information on terrestrial and aquatic organisms observed in the area of each farmer.

CONSERVATION OF HABITATS

Four artificial wetlands have been habilitated at canals of San Gregorio Atlapulco in order to improve water quality. We have data on water quality before the habilitation and one month after. These canals are part of the sampling sites we will evaluate.

CONSERVATION OF ECOSYSTEM SERVICES

Our study area is a Natural Protected Area with a major threat such as urbanization, preservation of traditional agriculture, maintenance of original channels, improving water quality and habitat for native species along with the improvement of water quality for irrigation, results in the enhancing of ecosystem services. Traditional agriculture means crops in open spaces instead of greenhouses, in order to increase green coverage. Water quality improvement means the maintenance of soil because we introduce aquatic plants which help to reduce salt content in water and later in soil. Organic manures also preserve nutrients. At narrow channels, by keeping out of it to introduced species, we look for the increasing of species richness on the bottom of food chain to promote the growing and reproduction of higher food chain levels such as Axolotl, an endemic, emblematic and very well appreciated in neuro-research amphibian.

CONSERVATION OF CULTURAL HERITAGE

Xochimilco is a World Heritage Site named by UNESCO. All work done by our NGO to preserve chinampas, recover the narrow canals, recover biodiversity, promoting environmental services, training local producers, is engaged in the preservation of this wonderful lacustrine area so near from a big City. Recently Xochimilco was named as SIPAM site

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