EXPLORATORY STUDY ON WATER AND SEDIMENT QUALITY
AT SAN GREGORIO ATLAPULCO CANALS. XOCHIMILCO, MÉXICO

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2016-2018
Dear Volunteers,

We have come to the end of our project with a lot of interesting results. Looking back at our sampling seasons with the different volunteer groups, we didn’t only learned scientific facts, but we also learned how to see our research through your eyes. That has helped us a lot to communicate science to the society. It has also helped us to ask ourselves questions that we had not thought about. We were also very proud to know that one of the volunteer groups won the prize for the best “Video contest”. It was fun undertaking the task with you!!

We are eager to meet some new volunteers and we would love to see some of you too again.

Thanks for the great effort you put into our research!

Sincerely,

Dr. Claudia Ponce de León

M. Sc. Elsa Valiente
SUMMARY

The good quality of the canals including the riparian area, sediments and zooplankton diversity are very localized, showing that canal management can make a great impact on making a good habitat for the axolotl. In particular, planting adequate plants and trees to consolidate the edges of the canals and prevent runoff from the farming area would be very helpful. Also, harvesting the aquatic plants periodically and introducing oxygen to the water column would improve the water quality for the aquatic organisms.

GOALS, OBJECTIVES, AND RESULTS

Goal

To identify drivers for the survival of the Axolotl, the endemic salamander and for the assessment of water and sediment quality for crop management along the San Gregorio lacustrine system.

Objectives

1. To assess water, zooplankton and riparian quality in the canal network through indices.
2. To assess C:N relationship in sediment along the canals of the lacustrine system.
3. To correlate the water, zooplankton and riparian indices and sediment quality in order to evaluate the influence of each one of them in search of the best places to raise axolotl.

RESULTS

Background information

The Mexico City valley has a long history. The first settlers arrived to the Texcoco Lake in 1168 A.D. and established themselves in the islands of the lake (Figure 1). In the year 1325, the Aztecs began to build the city of Tenochtitlan, which in the fifteenth century would be one of the largest cities in the world. Due to the scarcity of land in the system of lakes Texcoco, Zumpango, Chalco, Xochimilco and Xaltocan, small manmade islands called chinampas were built. To separate freshwater from brackish water, dams, aqueducts and dikes were made.
The construction and use of chinampas is an ancient knowledge that dates back several thousand years, some estimates suggest that the first chinampas were built nearly four thousand years ago. Originally, the chinampas were highly productive agricultural ecosystems where agricultural production reached a 200 thousand people. In the early sixteenth century, the lake system had 100,000 chinampas (Figure 2) with three to ten occupants in each one, reaching an area of 1500 km². After the conquest in 1521, the population declined dramatically due to wars, slavery and new diseases. The population was reduced by 90%, that is, to less than 30,000 people in what was the great Tenochtitlan.
In 1524 the Spaniards introduced new plants and pets, as well as grains and European farming technologies. Deforestation and intensification of agricultural work in large areas of the Valley of Mexico were developed. From then on, dramatic changes in the geography of the valley took place. In fact, the Valley of Mexico is a transformed system that has suffered the consequences of human activity since pre-Hispanic times when the chinampas were built in the southern part of the lake.
Figure 3 shows the gradual drying up of the lake in order to gain land for cultivation, and later to flood control. But just as fertile agricultural land gains, it is lost to urbanization. From 1987 to 2000, the area was reduced by almost 20%. As a consequence, together with urbanization, the need for potable water has reduced not only the lakes but the ground water of the entire Mexico City basin. One of the most notorious places for these changes is the Xochimilco area where reminiscence of the ancient agricultural area still exists. The growing demand for potable water in the basin significantly reduced the supply of good quality surface water to the Xochimilco canal system[1] which in turn had to be replaced with wastewater from the megalopolis. This has had repercussions on a growing salinization of the lacustrine system and a drenching of the lower parts. In addition, the contribution of urban waste, the intensive use of fertilizers and the dumping of wastewater has encouraged the entry of nutrients and pollutants into the system, endangering or decimating endemic plant and animal species. The present project aims to produce a risk assessment of the water in the canals of the still agricultural area of San Gregorio Atlapulco. The area is bombarded by multiple social, economic and environmental problems and therefore in order to accomplish changes, all areas have to be tackled.

**STUDY SITE**

Figures 4 shows the location of the studied site. The studied site, San Gregorio Atlapulco (SGA), sits in the southern east part of Mexico City. Its agricultural system from chinampas, is a successful example of periurban agriculture, but, nevertheless is threatened by the urbanization and its consequences. The water canals cover a very large area and have a capricious layout. Therefore the sampling was done following previous sampling sites plus places where the endemic axolotl have been spotted.
Figure 4. The studied site, San Gregorio Atlapulco, in the protected area of Xochimilco in the southern part of Mexico City.
Figure 5 shows the exact location of the sampled sites. The sampling points located to the west (Fig. 5a) of SGA adjoin with Xochimilco wetland, the conservation lake and the urban area of SGA town. These sampling points are more impacted by the drainage of urban area and irregular human settlements inside of chinampas. On the other hand, the east sampling points (Fig. 5b) adjoin with the SGA swamp, a small part of urban area of SGA town and the greenhouses of San Luis Tlaxialtemalco town, which detent a high production of ornamental plants with an intense use of chemicals.

The chinampas of SGA cover an extension of 207 ha. Due to the constant extraction of water from the aquifer, the chinampas next to urban area show a distance from the water to the
land of 3.5 - 5.5 m, while at the chinampas next to the conservation lake, the distance is 0.10 - 0.80 m.

Due to this differential sinking, the farmers have built barriers in the canals in order to contain the water for irrigation of the chinampas, forming a network of canals with different physical and water conditions. Therefore, the sampling was oriented to cover as much different environments as possible in order to test water physicochemicals parameters, nutrients, heavy metals and biological parameters such as zooplankton and riparian and aquatic vegetation.

In total, seventy sites were sampled in the chinampas area of San Gregorio between 2016 and 2018. All water samples were obtained in the middle of the canals and at half the water column. All sites were sampled during the dry season. It is worth mentioning that a 7.1 earthquake hit the Mexico City area with the village of San Gregorio being one of the most affected, thus disturbing the temporal studies.

![Sampled sites located at the west area of San Gregorio wetland](image)

Fig. 5a. Sampled sites located at the west area of San Gregorio wetland
Objective 1. To assess water, zooplankton and riparian quality in the canal network through indices.

After the results of 2016 and 2017 showing no zonification of water quality could be attained, quality indices were evaluated for all the different sampled sites. A quality index aims at assessing the quality of water on the basis of one system which converts all the individual parameters and their concentration into a single value. The acquired indices in our study were biological, physicochemical and riparian.

*Physicochemical water indices*

There are a variety of indices that can be used that can describe the quality of water based on the physicochemical parameters of water. Numerous water quality indices have been formulated all over the world assessing easily overall water quality within a particular area.
Water quality indices WQI can be divided into two categories, the single or the comprehensive assessment method[2]. In this study, we used the Single Assessment method which assesses the water quality category of each assessment factor criteria, and using the worst category as a final result of water quality assessment[3].

In this way, the WQI based on the work from Conesa [4] was used as the main WQI for years 2016, 2017 and 2018. The overall WQI for the three years did not show significant differences between the years, therefore it seems the 2017 earthquake in Mexico City did not have a significant impact on the water quality index; also showing that the water quality in the San Gregorio area does not change dramatically along the years. Nevertheless, some specific sites did show differences when compared to 2018 (8 months after the earthquake). Sites 1C, 6B, 7C, 9A-C, 10A, 10B showed 2017 and 2016 with a considerable better water quality when compared to 2018. The difference in water quality in the years previous to the earthquake for sites 1C, 6B, 7C could be explained by the effect of the earthquake since these sites were some of the sites that were most impacted.

As for the quality of the sampled sites, 15 samples along the three studied years showed a “good” water quality and the rest of the samples showed a “medium” water quality according to Jonnalagadda and Mhere [5]. The parameters that had the most impact in diminishing the quality of the water were total coliforms (median score of 10), sodium (median score of 50), dissolved oxygen (median score of 0), BOD (median score of 30), ammonia (median score of 0), and nitrates (median score of 30). Some of these parameters have already been reported to be a problem in the area, but never before had their impact in the overall quality of the water being evaluated. This is valuable information in order to tackle the parameters that would have the most impact in increasing the water quality of the area.

Another water quality index evaluated in this study was an index proposed for fish pond water quality in aquaculture. The aim of our study is to assess which canals could be used for the reintroduction of axolotl; therefore we hypothesized that this index could be helpful in assessing the ideal water quality for the axolotl. This index uses the particulate organic matter POM as a suitable, fast and cheap indicator of water quality [6] for fish farming. The POM index for the sampled sites in 2017 and 2018 are shown in Figure 6. It can be seen that higher POM indices were found in 2018 compared to 2017 with an average of 29.3 and 18.1 respectively. Also, higher variability was obtained for 2018 than 2017 (31 and 13 respectively); nevertheless the median for 2018 and 2017 were similar (17.6 and 14.3) suggesting that only some specific sites had a dramatic change in their POM index. This could be explained due to a flooding and/or the earthquake that occurred during 2017 after the sampling period. All the same, the graph shows that most of the sites are at an acceptable level and very few surpass a tolerable POM index level.
Biological indices

The Shannon-Wiener Diversity Index SWDI is one of the measures used in this study to try to obtain information of the organism status from the samples in the field. The results of the Shannon-Wiener index combine two quantifiable measures: species richness (number of species within community equity) and the species abundance[7, 8]. This index is used in ecology or other similar sciences to measure biodiversity, it is normally represented as $H'$ and is expressed with a positive number. In most natural ecosystems, $H'$ varies between 0 and has no upper limit or in any case is given by the base of the logarithm used. The ecosystems with the highest values are tropical forests and coral reefs, and the lowest are desert areas.

In this way, SWDI were determined for the sampled sites in the years 2017 and 2018 (Figures 7a and 7b). The values ranged from 0 to 1.72. Since diversity is a logarithmic measure, its relatively asymptotic character decreases the sensitivity of the index in the range of values near the upper limit such as sites 6A, 7A, 14A, 16C and 18B in the year 2017, while for the year 2018 sites 6B, 9A and 19A showed that sensitivity. Low values are considered an indication of a negative effect on diversity such as at site 12A in 2017, and for 2018 sites 18B, 20A and 20B. However, it should be noted that a significant difference of 0.05 was determined in an analysis of variance between the Shannon-Wiener index determined in
2017 and that of 2018 according to the diversity of zooplankton. A good diversity is observed in the year 2017 for sites 6A, 7A, 14A, 16C and 18B for 2017, on the contrary only one site, 12A, had null diversity. Another site with low diversity was 11B with 0.03 of Shannon-Wienner index. For 2018, zero diversity were observed in more sites, such as 18B, 20A and 20B, showing in general a diminished Shannon-Wienner index for most sites; for 2017 the average diversity Shannon-Wienner index was 1.04 and for 2018 there is a 69% decrease with an average diversity the Shannon-Wienner index of 0.719.

Figure 7a. Shannon-Wiener Diversity Index for the 2017 sampled sites in San Gregorio
**Riverine indices**

Riparian habitat can support a high biodiversity, protect the main canal from temporal changes and buffer large disturbances [9]. In the Xochimilco wetland, riparian vegetation might help to retain the runoff with pesticides and nutrients from agriculture.

In order to assess the quality of the riparian vegetation in the San Gregorio wetland, we used the principles of the Riparian Forest Quality Index (Qualitat del bosc de Ribera Index, QBR) originally applied to rivers in three catchments of Spain [9].

The index differentiates the main channel and the riparian area. The main channel refers to the area of the canal with permanent water flow. The riparian area is located between the highest flooding level and the beginning of the plain area. The QBR index summarizes four scores to assess the quality of the riparian area and it also uses several criterions to adjust the final score according to the smaller differences. The data analysis showed only one site with natural condition, located at the San Sebastian lagoon. Figure 8 shows the frequency of sampled sites and distribution according to the quality classes.

Figure 7b. Shannon-Wiener Diversity Index for the 2018 sampled sites in San Gregorio
San Gregorio Wetland, west region.- The west region of the SGA wetland is contiguous to the Xochimilco Lake and to the Conservation Lake. Xochimilco and SGA share a swamp that gets flooded during the rainy season. Between the first two sampled sites, Tecaltitla (2) and Puente de Urrutia (20), there are irregular human settlements, greenhouses for ornamental plants with an intensive use of agrochemicals, cattle rising and traditional chinampas, some of them in use and many others abandoned.

At this area there is a subsidence process documented since 2012 by the Procuraduría Ambiental y del Ordenamiento Territorial del Distrito Federal PAOT. Some of the chinampas adjoined to the conservation lake actually sank during the last earthquake in 2017. There is a slope that goes from south to north, from the urban area to the wetland.

In the central area of the west region (Sites 6, 13, 14, 15 and 18) the water flow is obstructed with dams made of sand sacks built by the farmers in order to avoid the flooding of the chinampas. However there are two contiguous sites that show good riparian quality since there is more shrub diversity, there are more trees and the connection between the riparian and the land vegetation is uninterrupted.

However, most of the sites at this region show strong alteration. The low QBR score at these sites is due to the low quantity of trees and shrubs and low connectivity between the canals.

Sites 10 and 1 are located at canals that receive water from the urban area and are within the largest irregular human settlements inside the chinampas. The riparian quality at 10C and 1C sites show extreme and strong alteration as they are contiguous to houses and the embankments are concrete made.

San Gregorio Wetland, central region.- The central region of the wetland has three sites, Coapatitla canal (Site 3), El Bordo (Site 4) and La Espejera (Site 19).
Coapativtla canal goes from the urban area to the chinampas with grown crops. The beginning of the canal presents tall riparian walls in the canals and thus low connectivity to the mainland; additionally, sewage water from the houses at the edge of the canals. But then as it goes into the chinampa area, the water and the land are almost at the same level; however the low diversity and structure of shrubs rates the QBR with important disturbance and only fair quality.

Site 4C, has low abundance of trees and shrubs, low connectivity and channelization departs a canal that crosses a wide area of helophytes. The site 4B is located just in the middle of helophytes thus showing good quality of QBR. This canal reaches the border of the wetland next to a broad road; therefore the QBR index lowers.

Site 19 improves its quality from site 19C located next to a rigid structure, to the 19 A which has high connectivity, helophytes and a good score for trees and shrubs.

In general, the variables that had the most significant impact on the QBR index, were the vegetation coverage and structure and even though the canal alterations had the least impact on the QBR index, it had the highest variability. Quality of vegetation coverage had medium impact and low variability. These results imply that managing the vegetation on the edges of the canals could improve the QBR without relying on fixing the canals alterations that is difficult to tackle.

**Objective 2. To assess C:N relationship in sediment along the canals of the lacustrine system.**

Sediments are important for the overall health of the aquatic ecosystems as they have a variety of functions: natural trap for diverse substances including pollutants, storage of organic carbon, regulating processes for the water column and a source of nutrients influencing primary productivity. Therefore, sediment characterization is an important tool if a complete assessment of the condition of the canals is to be made. Texture and C:N were the variables measured to elucidate the sediment quality of the San Gregorio canals. The median and the standard deviation of data for texture and C:N ratio showed no significant differences between 2017 and 2018. Nevertheless, C:N ratio had variations between the sampled sites as can be seen in Figure 14. On the other hand, the C:N ratio from the sediments has been used as a proxy to explain the origin of the sediments. In our study, the C:N ratio varied from 10 to 15, signifying that the origin of the sediments is terrestrial organic matter[10]. Likewise, it also reflects that organic matter is in the process of humification, since its values 10 to 20 correspond to decomposition principles of organic matter [11] suggesting that the constant contribution of organic matter does not allow the complete mineralization processes in the sediments. This can be explained from the constant runoff from the
chinampas since the riparian areas are not very consolidated and the farming areas are not more than 2 meters from the canal.

Interestingly, macrophytes are common in the mostly shallow canals, however the C:N ratio is not dominated by their decomposition (approximately 39 C:N ratio)[12] suggesting a quick degradation of these plants.

Another important information given by the C:N ratio is the nutritional value of the sediment. C:N ratios of 10 or greater, as in our data, are of low nutritional value for sediment-ingesting organisms[13]. Therefore Alonas and cladoceran zooplankton, common food for the axolotl[14], cannot obtain quality food hence impacting its proliferation. This in turn can be a deterrent for the propagation of axolotl.

![Figure 14. C:N canal sediment ratio for 2017 and 2018 in San Gregorio.](image)

**Objective 3. To correlate the water, zooplankton and riparian indices and sediment quality in order to evaluate the influence of each one of them in search of the best places to raise axolotl.**

Ideally, there should be a clear correlation between the water quality, the riparian status of the canals and the zooplankton diversity. The results from 2017, showed a clear correlation between some zooplankton species and the depth and width of the canals. Nevertheless, when a correlation analysis is obtained for the zooplankton (Shannon index) and water quality
indices (WQI and POM) from 2017 and 2018 and riverine 2018 (QBR), no noteworthy correlation could be found as shown in Table 1. An obvious correlation was found for the WQI for 2017 and 2018 telling that the water physicochemical parameters are preserved from one year to another. Interestingly, the zooplankton diversity changed from one year to the other, although both samplings were made in the same month of the year. This result suggests considerably more dynamic changes for the zooplankton and that a much closer monitoring of the zooplankton dynamics is in place.

On the other hand, a negative correlation was found between POM 2017 and the riverine index. A negative correlation could be explained by less runoff from the chinampas and therefore less suspended particles with high organic matter content, with more riparian vegetation and consolidated embankments. It must be clarified that this explanation is considering that riverine characteristics do not change greatly from one year to another, therefore although the riverine data is from 2018, it is expected that the QBR was the same for 2017. No correlation was found between QBR and POM 2018 which was not anticipated. Nevertheless, a cluster multivariate analysis for variables showed POM 2018 and QBR forming a group with same Euclidian distance (Figure 8). The lack of a clear correlation between POM 2018 and QBR could be explained by the fact that the median for POM 2017 and 2018 (14.3 and 17.6 respectively) were similar but the standard deviation for 2017 was smaller than for 2018 (13.0 and 31.0 respectively). As explained before, the higher standard deviation of POM 2018 could be due to a flooding that occurred in the rainy season of the previous year, and/or the earthquake that left cracks and subsidence in some canals and chinampas.

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<td>Shannon 2018</td>
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The cluster analysis for 2017 indices (including 2018 BQR), showed a grouping between zooplankton index (Shannon-Wienner) and the riverine index (QBR) as seen in Figure 9. A second grouping can be seen between WQI, BQR and Shannon-Wienner indices. This grouping conveys that, as expected, zooplankton population depends on the water quality and the riverine characteristics. Conversely, POM does not group with the other variables. It was hypothesized, that since POM was suggested as a good indicator for fish pond water quality, this index could work for zooplankton as well, but this does not seem to be the case.

It is interesting to note that zooplankton index for 2018 does not correlate with any of the other indices. It is clear that some drastic change occurred in the zooplankton community between 2017 and 2018 and further studies have to be made to determine if this is a normal behavior or a onetime occurrence.
As for the grouping of the sites, the multivariate cluster analysis in Figure 10. shows no relevant grouping. These results indicate again, much localized water qualities depending on the management of the canals and the riparian borders.
Figure 10. Site multivariate cluster analysis for indices b) 2017

Therefore maps showing the quality of water, riverine borders and zooplankton diversity should prove very helpful to assess if the desired canals are suitable for reintroducing axolotl, as shown in Figures 11, 12 and 13. This comparison shows that the best place for axolotl should be 19A followed by 6B and then 9A. The sites are rich in large clodocera and Simocephalus vetulus with an assortment of sizes, ideal axolotl food. It should be noted that the sites are quite specific, since adjacent sites do not show the same good quality indexes.
Figure 11. WQI for the water sampled sites showing the value of the sites.

Figure 11. QBR for the riparian sampled sites showing the value of the sites.
CONCLUSIONS

The water quality index showed that only 15 samples along the three studied years showed a “good” water quality and the rest of the samples showed a “medium”. The physicochemical parameters that had the most impact in diminishing the quality of the water were total coliforms, sodium, dissolved oxygen, BOD, ammonia, and nitrates. As for the particulate organic matter index POM, the median for 2018 and 2017 were similar suggesting that only some specific sites had a dramatic change in their POM index.

The zooplankton studies revealed that for 2018, more sites with null diversity shown by the Shannon-Wienner index were observed. In this way, in 2017 the average diversity Shannon-Wienner index was 1.04 and for 2018 there is a 69% decrease showing that zooplankton diversity changed from one year to the other, though both samplings were made in the same month of the year. This result suggests considerably more dynamic changes for the zooplankton and that a much closer monitoring of the zooplankton dynamics is in place.

The riparian studies showed that the variables that had the most significant impact on the QBR index, were the vegetation coverage and structure and even though the canal alterations had the least impact on the QBR index, it had the highest variability. Quality of
vegetation coverage had medium impact and low variability. These results imply that managing the vegetation on the edges of the canals could improve the QBR without relying on fixing the canals alterations that is difficult to tackle.

C:N sediment ratio studies showed that the origin of the sediments is terrestrial organic matter and that the organic matter is in the process of humification; thus suggesting that the constant contribution of organic matter does not allow the complete mineralization processes in the sediments. Another important information given by the C:N ratio is that nutritional value of the sediment is low for sediment-ingesting organisms.

The correlation analysis for the zooplankton (Shannon index) and water quality indices (WQI and POM) from 2017 and 2018 and riverine 2018 (QBR), gave no worth mentioning correlation. Nonetheless, the multivariate cluster analysis grouped WQI, BQR and Shannon-Wiener indices. This grouping conveys that, as expected, zooplankton population depends on the water quality and the riverine characteristics. It is interesting to note that zooplankton index for 2018 did not correlate with any of the other indices. It is clear that some drastic change occurred in the zooplankton community between 2017 and 2018 and further studies have to be made to determine if this is a normal behavior or a onetime occurrence. As for the grouping of the sites, the multivariate cluster analysis did not show any relevant grouping. These results indicate again, much localized qualities depending on the management of the canals and the riparian borders. In this sense the best place for axolotl should be 19A followed by 6B and then 9A but none of the adjacent sites. The sites are also rich in large clodocera and Simocephalus vetulus with an assortment of sizes, ideal axolotl food.

PROJECT IMPACTS

1. Increasing Scientific Knowledge

a) Total citizen science research hours
   Field training 1 hour
   Field data collection 6 hours
   Field material preparation 3 hours
   Field samples unloading and packing away 1 hour
   Data saving in computer 3 hours
   Field transportation 2 hours
b) Peer-reviewed publications


c) Non-peer reviewed publications:

d) Books and book chapters

e) Presentations:

"Evaluación de la Biodisponibilidad de metales en sedimento de la zona chinampera de Xochimilco, Ciudad de Mexico" Francisco Jurado Diana. Ponce de León Claudia Alejandra, Hernández Quiroz Manuel. IV congreso de la sociedad de análisis de riesgo latinoamericana SRA-LA -2018. Octubre 29-31 de. INVITED SPEAKER


2. Mentoring

a) Graduate students

<table>
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<th>Student Name</th>
<th>Graduate Degree</th>
<th>Project Title</th>
<th>Anticipated Year of Completion</th>
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<td>Jorge Meza</td>
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<td>Evaluación Cualitativa de los Contaminantes Orgánicos en Agua de los Canales del Área Protegida de Xochimilco.</td>
<td>February 2019</td>
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b) Community outreach

<table>
<thead>
<tr>
<th>Name of school, organization, or group</th>
<th>Education level</th>
<th>Participants local or non-local</th>
<th>Details on contributions/ activities</th>
</tr>
</thead>
</table>
| Farmers of San Gregorio Atlapulco     | No school to undergraduate | Local | - REDES AC continues with the support to the short marketing chain of EcoQuilitl.  
- A new group named Fresco Axayaya was formally launched in Instagram. They also have a brochure, a digital catalog and presentation cards.  
- Redes continue working in the launching of the Atlapulco Ecotouristic Group. They have received talkings on Federal Normativity and marketing. Their dateline to begin working in ecotourism is February 2019.  
- The farmer Ramiro Serralde is about to launch his brochure. The name of his entrepreneurship is RAB sprouts. |
Farmers of San Mateo Xalpa
No school - undergraduate
Local
The group of farmers from San Mateo has also been followed up, however they have had internal issues in his organization and this situation has delayed the process to form the agrotouristic group. Nevertheless, Redes is working with them and the goal is to launch the entrepreneurship by July 2019.

Farmers from San Gregorio and San Mateo Xalpa
No school - undergraduate
Local
REDES AC is beginning a new project on sustainable water management founded by “Fundación Gonzalo Río Arronte” in the frame of its Water Program. The goal is that both groups, located in the lower and upper sub-basin learn to improve their water management in their cattle, agriculture and domestic activities and help them to understand the impact of their activities in water quality. The project also will install 22 rain catchment systems and 9 dry bathrooms. Both systems intend to assist in the mitigation of water pollution due to sewage. The location of the dry bathrooms in San Gregorio wetland will be supported on the coliform bacteria and E. coli hot spots found during the Earthwatch water quality research.

3. Partnerships

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<th>Support Type(s)</th>
<th>Years of Association (e.g. 2006-present)</th>
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<td>Funding, logistics, technical support, collaboration</td>
<td>2016- present</td>
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<tr>
<td>Casa de Cultura San Gregorio Atlapulco</td>
<td>Infrastructure for sessions and dining room.</td>
<td>2016 - present</td>
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1 Support type options: funding, data, logistics, permits, technical support, collaboration, academic support, cultural support, other (define)

4. Contributions to management plans or policies

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<th>Plan/Policy Name</th>
<th>Type</th>
<th>Level of Impact</th>
<th>New or Existing?</th>
<th>Primary goal of plan/policy</th>
<th>Stage of plan/policy</th>
<th>Description of Contribution</th>
</tr>
</thead>
</table>

5. Conserving natural and sociocultural capital

a) Conservation of taxa

iii. List any focal study species that you did not list in your most recent proposal

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>IUCN Red List category</th>
<th>Local/regional conservation status</th>
<th>Local/regional conservation status source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambystoma mexicanum</td>
<td>Axolotl / Ajolote</td>
<td>Critically endangered</td>
<td>In danger of extinction</td>
<td>NOM-059-SEMARHAT/2010</td>
</tr>
</tbody>
</table>

iv. In the past year, has your project helped conserve or restore populations of species of conservation significance? If so, please describe below.
b) Conservation of ecosystems

In the past year, has your project helped conserve or restore habitats? If so, please describe below.

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Habitat significance</th>
<th>Description of contribution</th>
<th>Resulting effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland canals</td>
<td>Breeding ground</td>
<td>Schooling the management of the canals and farmland to increase water quality</td>
<td>Improved resilience</td>
</tr>
</tbody>
</table>

| Habitat significance options: nursery, breeding ground, feeding site, corridor, migration path, refuge, winter range, summer range, spring range, fall range or other (define) |
| Resulting effect options: extent maintained, condition achieved, restored, expanded, improved connectivity or resilience |

c) Ecosystem services

Indicate which ecosystem service categories you are **directly studying** in your Earthwatch research and provide further details in the box below.

- Food and water
- ☐ Flood and disease control
- ☐ Spiritual, recreational, and cultural benefits
- ☐ Nutrient cycling

Details:

The project studies two of the main ecosystem service that the wetlands of Mexico City provide: food and water. Regarding food, Xochimilco wetlands was declared in 2017 as a Globally Important Agricultural Heritage Systems” (GIAHS), which are outstanding landscapes of aesthetic beauty that combine agricultural biodiversity, resilient ecosystems and a valuable cultural heritage (http://www.fao.org/giahs/en/). The chinampas, which are the land plots dedicated to agriculture, are about to disappear due to the low income from As for water, Xochimilco wetlands provide 69% of the water source of Mexico City. The overexploitation of the aquifer and the pollution of water with sewage and chemicals makes the land use and land management at Chinampas are crucial for water quality. Therefore this project aims to understand the key factors that contribute more to water pollution and the links among water quality, primary consumers and riparian vegetation.

d) Conservation of cultural heritage

<table>
<thead>
<tr>
<th>Cultural heritage component</th>
<th>Description of contribution</th>
<th>Resulting effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional agriculture at Chinampas</td>
<td>Traditional farming at wetlands has two main bottlenecks: water (lack and quality) and market. EY volunteers have developed a business plan to tackle on different activities and markets, to do a better resource management and improve their income.</td>
<td>Farmers have more acquaintance of the extent of their potential. Currently there are two groups of farmers, EcoQuilitl and Fresco Axayopa, who are selling their products directly to consumers.</td>
</tr>
</tbody>
</table>
REDESAC has also worked on the sustainability assessment of the farmers. Four farmers, Azael Meléndez, Ramiro Serralde, Crescencio Hernández and Eloísa Serralde are also selling directly to consumers.

Two groups of farmers, San Mateo Xalpa and Atlapulco are working to become ecotouristic groups. All of them are using the material and proposals left by EY volunteers and all of them have developed their brochure, logo, mission and vision and are willing to grow as entrepreneurs.

Learning on water quality and biodiversity has helped them to understand the importance of their activities for the preservation of the wetland and its biodiversity.

Cultural heritage component options: traditional agriculture, artifacts, building(s), hunting ground or kill site, traditional ecological knowledge and practices, monument(s), oral traditions and history, spiritual site, traditional subsistence living

RESEARCH PLAN UPDATES

Report any changes in your research since your last proposal/annual report. For any ‘yes’ answers, provide details on the change in the ‘Details’ box. This section will not be published online.

1) Have you added a new research site or has your research site location changed? ☐Yes ☒No
2) Has the protected area status of your research site changed? ☐Yes ☒No
3) Has the conservation status of a species you study changed? ☐Yes ☒No
4) Have there been any changes in project scientists or field crew? ☐Yes ☒No

Details - provide more information for any ‘yes’ answers

5) Provide details on any changes to your objectives, volunteer tasks, or methods, include reason for the change.

A new proposal was submitted to continue the study of Xochimilco wetlands. The objective of the project is to restore the basic conditions of the habitat of the axolotl *Ambystoma mexicanum* in specific canals that can be maintained and conserved as sanctuaries within a wetland with agricultural use and housing land. The primary question is whether the controlled management of artificial wetlands within the canals of the lacustrine system, would allow the purification of water and sediments in a way that favors an optimal habitat for the development of a population of axolotl.

ACKNOWLEDGEMENTS

We would like to thank our technician Manuel Hernandez and the biology student Carolina Francisco for all their support in the field and with the laboratory analyses.

We also want to give a special recognition to the farmers, for their support in the field.
To all EY volunteers for their hard work and enthusiasm during the research activities and skills-based job with farmers.

To the field team: Dana Salomon, Keegan Dougherty, Manuel Hernández, Diana Francisco, Jorge Meza, Ximena Mendoza, Erika Rodríguez, Erick Hjort, Renato, Adela and Herándira Flores for their commitment to achieve a safe and enjoyable experience to volunteers.

LITERATURE CITED