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Management and key problems identification of selected sites for the sustainable reintroduction of axolotl

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Annual Field Report 2019

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LETTER TO VOLUNTEERS

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Dear Volunteers,

We have initiated our second Earthwatch project, moving into putting in action the knowledge we acquired during the first project. This new project has been challenging but your participation was great. The images taken by your drone were so helpful. We could get a better understanding of the influences and challenges our project is facing.

Your work with the farmers has become popular and sought by the farmers, and we too have learned a lot while picking your brain! 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.

Therefore, our primary question in this research 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 an Axolotl population.

In the 2019 field season, the research team has advocated to the understanding of the dynamics of four canals, located at the San Sebastian area, inside the natural protected area of "Ejidos de Xochimilco y San Gregorio Atlapulco".

GOALS, OBJECTIVES, AND RESULTS

GOAL

To identify the environmental conditions and environmental, socio-economic management of the canals for the survival of the axolotl along the San Gregorio lacustrine system

OBJECTIVES

1. To find the environmental conditions and management to recover the population of Axolotl in its natural habitat.
2. To identify and generate mitigation methods for contaminants that could potentially have a negative impact on the development of Axolotl.
3. Propose mitigation measures in the management of the chinampas that result in a better quality of habitat for the axolotl in the canals.
4. Involve the farmers in the monitoring and management in the care of the axolotl
5. Show the farmers how the management of the canals for the axolotl can also benefit their socio-economic activities.

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.

Figure 1. Texcoco lake where the city of Tenochtitlan was established.

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 km^2. 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.

Figure 2. The chinampas used for food production in Aztec times.

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.

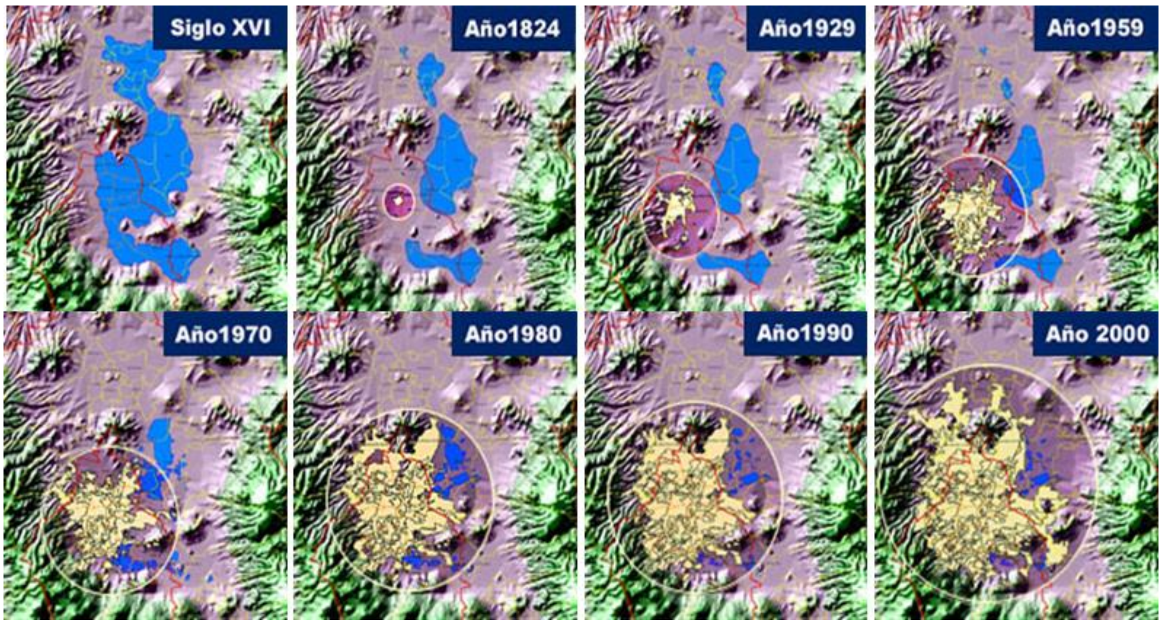

Figure 3. Gradual drying up of the lakes in the Mexico City Valley.

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.

Pollution, fragmentation and urbanization of freshwater ecosystems globally has led to the loss of species of ecological, economic and cultural importance, the environmental functions and services they provide to humans have also been altered and in several cases their Recovery is irreversible.

The impact of human activities on ecosystems has resulted in the extinction of 122 species since 1980, currently one third (32%) of amphibian species in the world are threatened and at least 43% of the species are going through population decline events. In America, 46% of salamander species are extinct or threatened.

In Mexico, amphibians of the Genus Ambystoma, Family Ambystomatidae, are composed of 28 species, of which 17 are distributed in our territory. Four of these species (*A. lacustris, A. lermaense, A. mexicanum and A. dumerilii*), do not carry out metamorphosis to salamanders, so that their entire life cycle is aquatic and they are found in isolated lakes in the states from Puebla, Mexico, Federal District and Michoacán respectively.

Mexico has experienced a high percentage of deforestation and land use change in recent years, which has led to a negative impact on several amphibian populations, one of which is *Ambystoma mexicanum*, endemic to Mexico City at Xochimilco canals and listed as endangered species (P) by NOM-059-SEMARNAT-2010, in spite of its high cultural, gastronomic and ecological importance.

This specie, known as Axolotl, is in serious danger of extinction. Its main threats are the lack of enough and suitable food due to the feeding competition by invasive species, carp and tilapia; the lack of oxygen in the bottom of the canals, which is critical in the first two weeks of developing stages and the increasing of water temperature lead by loss of tree vegetation in the edges of chinampas. The decline of its population has been registered since 1998, with the first population census in its natural habitat, which determined 6 ind/km^2, then in 2002, the estimation was 1 ind/ Km^2 and the last monitoring, in 2008, gave 0.01 ind./Km^2

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. For comparison purposes, 4 sites were chosen: two control canals (LUC and CRC) and two experimental (LUE and CRE) as shown in Figure 5. The acronyms originate from the chinampa´s owners name (Luis and Crescencio). Additionally, each canal was subdivided in four sections and in each section measurements were made on the top (superficial) and bottom of the water column. Also, morphology and botanical analysis were made in the canal walls and the sides of the canal.

Figure 4. The studied site, San Gregorio Atlapulco, in the protected area of Xochimilco in the southern part of Mexico City.

Figure 5. Sampled sites in the agricultural area of San Gregorio Atlapulco.

Figure 5 shows the exact location of the sampled sites. The chosen canals are within the agricultural area of two farmlands with no impact other than its own agricultural activities. In this way we can make sure that whatever intervention is done to the canals will mirror the results we find.

RESULTS AND DISCUSSION

During this first year of the project, it was of great importance the assessment of the canals' dynamic throughout the seasons of the year. Therefore physicochemical parameters (on-site and laboratory), canal and riparian morphology, phytoplankton and zooplankton were measured approximately each month during 2019. Unfortunately one of the canals had little to no water in the majority of the months during the year which hampered some of our results.

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PHYSICOCHEMICAL PARAMETERS

ON-SITE PARAMETERS

The on-site physicochemical parameters were obtained in the field with a portable multiparameter for water measurements. Transparency was obtained with a Secchi disc. All these parameters were obtained monthly along the four sections of the canals.

Temperature

Monitoring of water temperature is important because of its influence in all chemical processes. High temperatures accelerates the metabolism of bacteria and all the oxygen in the water can be consumed, giving rise to a state of anoxia in the aquatic environment where only anaerobic bacteria (strict or facultative) could survive. Other important variable that can be altered is the solubility of gases (oxygen, nitrogen, CO2, etc.).

In SGA we could observe that in general the temperature is a reflection of the seasons of the year with September having the highest temperatures and March through May the lowest. Water temperature is an unregulated indicator in Mexico and not required when water is used for irrigation. The values obtained (Figure 6) in the year 2019 had a maximum of 22.34 ° C, a minimum of 12.61 ° C with an average of 17.06 ° C and were lower than the maximum permissible limit (LMP) (<40 ° C) established by the Mexican norm for river water for urban public use NOM-001-ECOL-1996.

	LUC T	LUC B	LUE T	LUE B	CRC T	CRC B	CRE T	CRE B
Marzo	17.57±0.19	16.76±0.17	12.62±0.29	12.62±0.21	18.29±1.93	16.04±1.82	13.78±1.10	13.45±1.12
Abril	16.87±0.42		14.22±0.54		16.48±0.44	15.38±0.85		
Mayo	16.01±0.71	14.86±0.64	13.23±0.47	13.15±0.39				
Junio	17.64±0.03	16.52±0.13	16.23±0.86	16.34±0.78	19.63±0.47	16.83±0.31	22.34±0.13	22.18±0.24
Agosto	18.92±0.08	18.55±0.11	19.47±0.82	18.45±0.91	16.69±0.68	16.66±0.31		
Septiembre	20.28±0.57	20.21±0.07	20.13±2.60	19.63±1.33	18.40±0.53	17.83±0.86		
Octubre	18.09±0.37	18.06±0.38	18.39±0.67	17.93±0.58	17.25±0.47	16.65±0.31		
Noviembre	17.06±0.32	16.57±0.09	16.81±1.71	15.70±1.12	16.97±0.61	15.34±0.58		

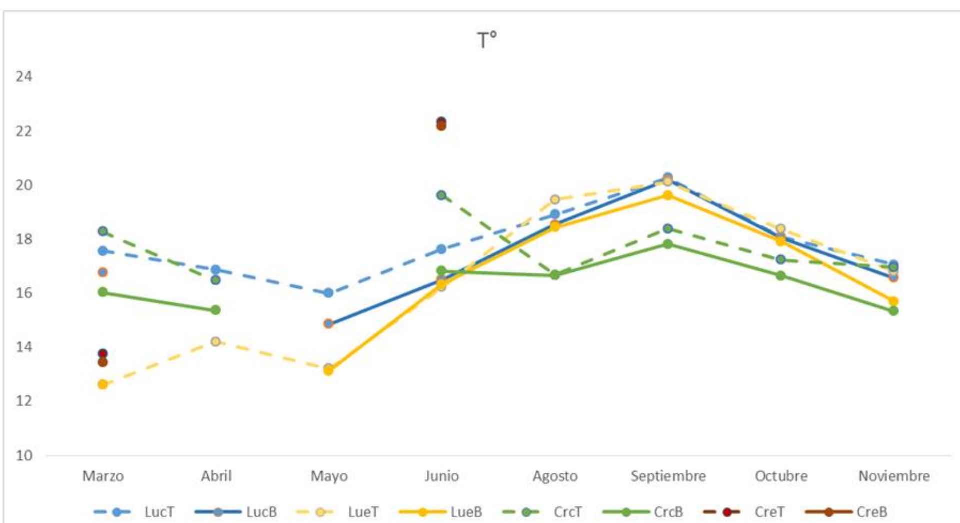


Figure 6. Temporal behaviour of the average temperature of the water from the studied canals. (T=Top; B=Bottom)

Dissolved Oxygen

Dissolved oxygen in the water column is critical for the survival of aquatic organisms and for several biogeochemical processes. For Axolotl, dissolved oxygen is relevant during the first stages, because the offspring lack of the back legs to swim to the surface, therefore, along with temperature and food, it is an important parameter to study.

Averages DO and profiles were measured with a HACH HQ40d probe, at each one of the sampling points along the control and experimental canals.

At both Control canals, it is observed a more regular pattern along the year, compared with experimental canals, which are closed. Nevertheless, oxygen concentrations are under zero and some peaks show 1.5-3 mg/L; these levels were recorded after some canal management, such as cleaning the canal or taking out the sediment (Fig 7).

Experimental canals show more variation in DO levels, but concentrations are always close to zero (Fig 8).

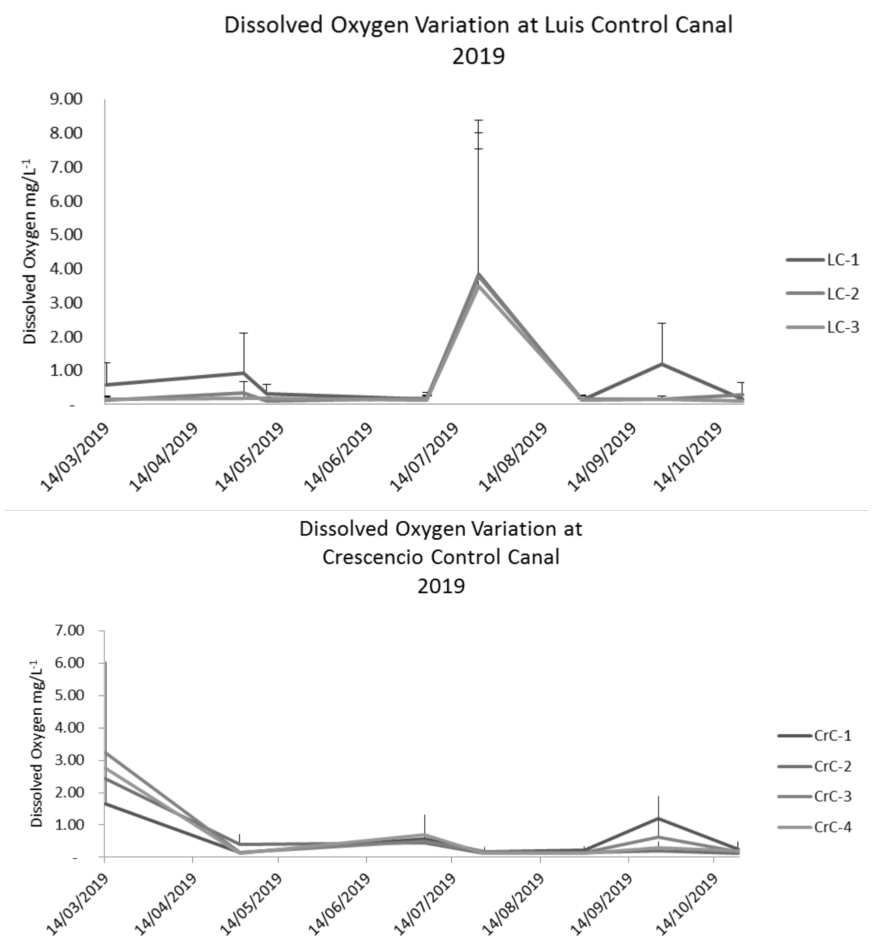
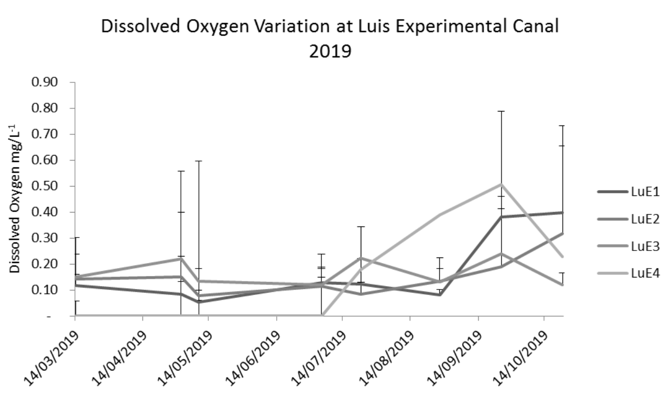


Figure 7. Average dissolved oxygen at the control canals



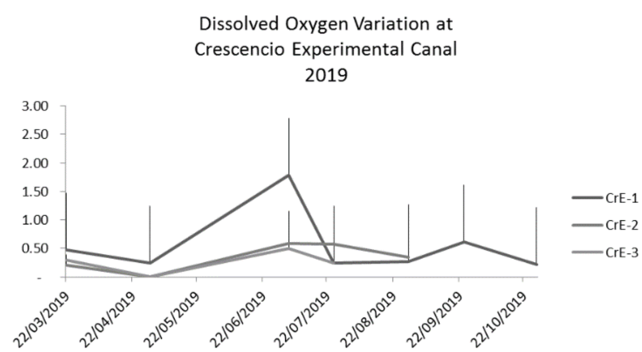


Figure 8. Average dissolved oxygen in the experimental canals

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Investigating the dissolved oxiygen along the water column is also of great importance. Profile graphs (Figure 9), LUC canal shows higher DO concentrations at the entrance of the canal which it is next to a small lake. However, as the sampling points approach to the end closed section of the canal, dissolved oxygen drops almost to zero, except in July, when the macrophytes of the canals were removed as part of a government program.

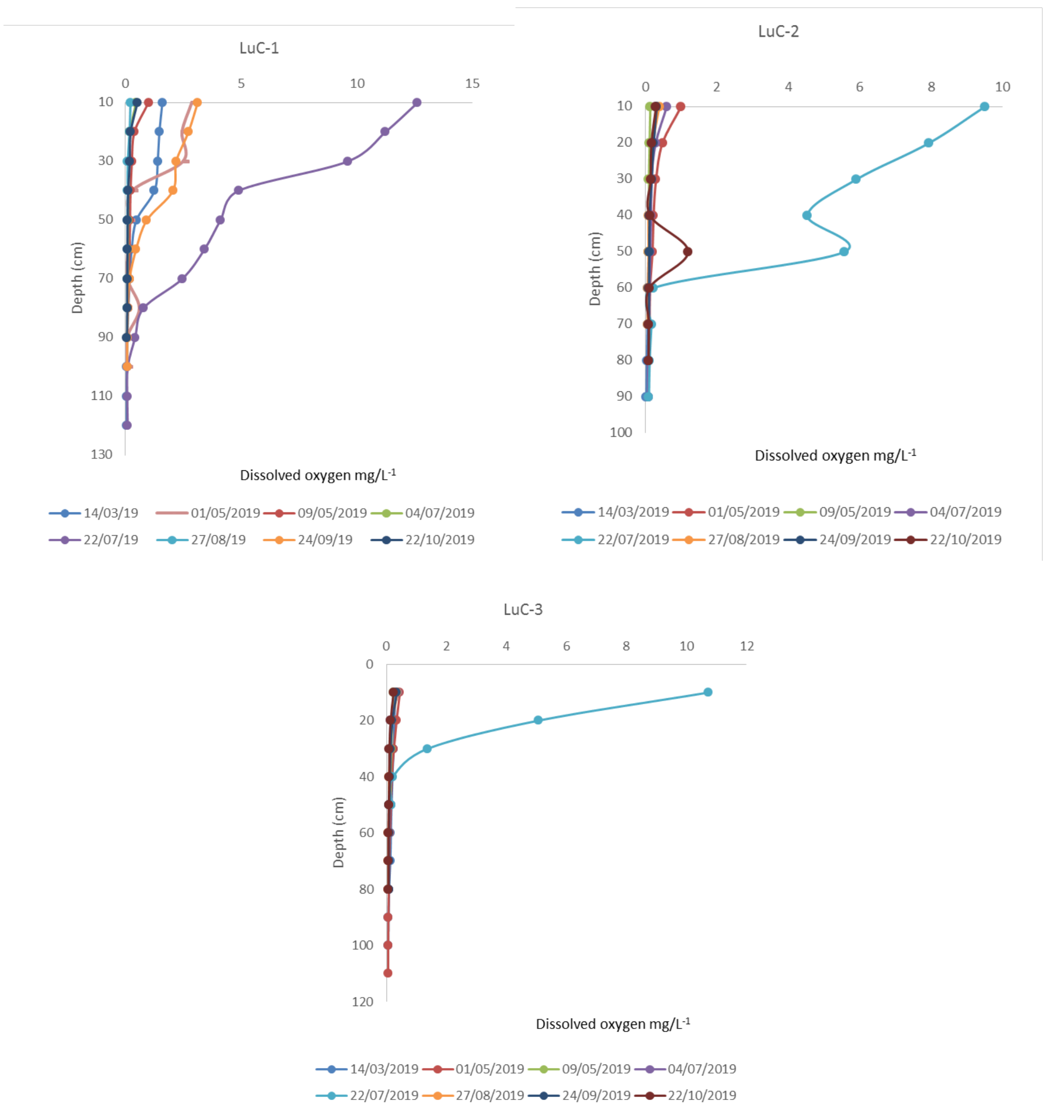

Fig 9. Dissolved oxygen profiles at each sampling point in Luis Control Canal

In the LUE canal (Figure 10), the DO is also under 1 mg/L, however it remains mostly in the same concentration at lower depths of water column. At LuE-1 the concentration is slightly higher because there are no trees in the edges and the water surface is at the same level than the land, therefore there is more oxygen exchange with the atmosphere. LuE-4, is located at a canal cleaned off vegetation in July and the DO concentration is higher, possible because it is connected with an exit to the small lake which surrounds the chinampa.

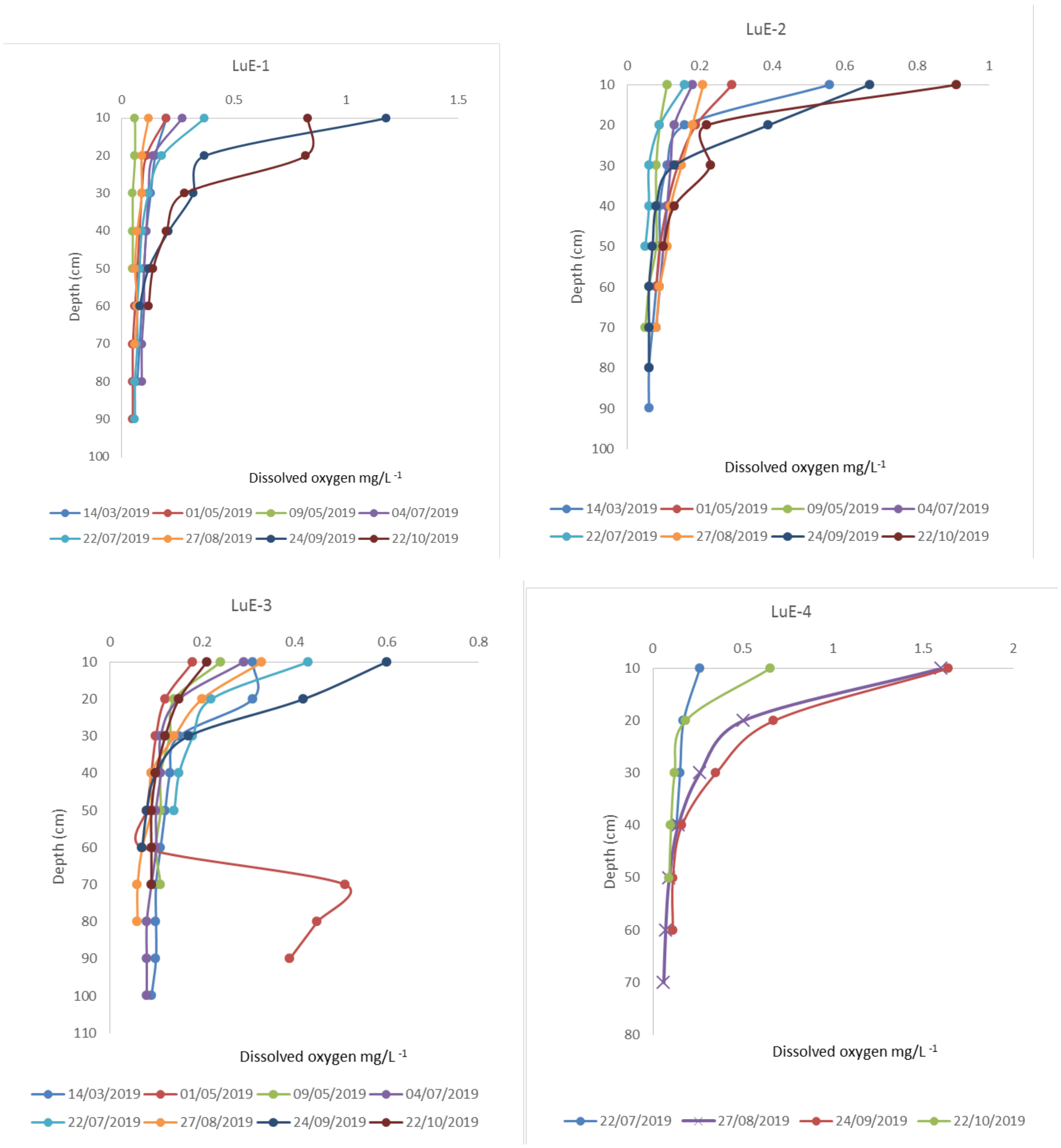

Fig 10. Dissolved oxygen profiles at each sampling point in Luis Experimental Canal

At the CRC canal (Figure 11), the DO profile shows higher concentrations on the surface (2-5 mg/L), but it immediately decreases as it approaches the bottom. The higher concentrations are most likely produced by the movement of the small boats that navigate through this canal.

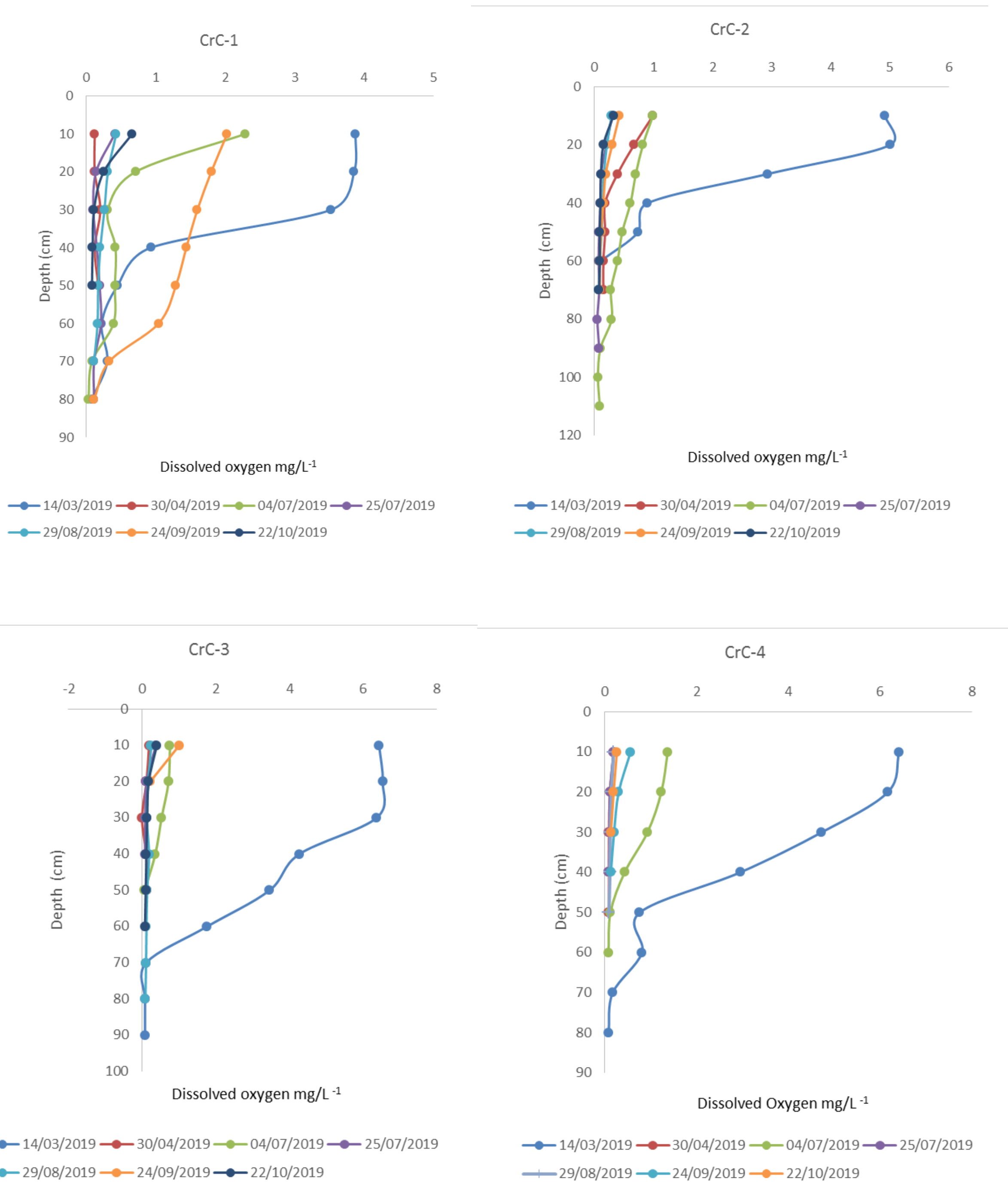

Figure 11. Dissolved oxygen profiles at each sampling point in Crescencio Control Canal

CRC canal (Figure 12) suffered of lack of water along the year, therefore the only sampling point with water was CrE-1, which is connected with a wetland canal and the main vegetation is *Typha latifolia.* The highest DO concentrations is on the surface.

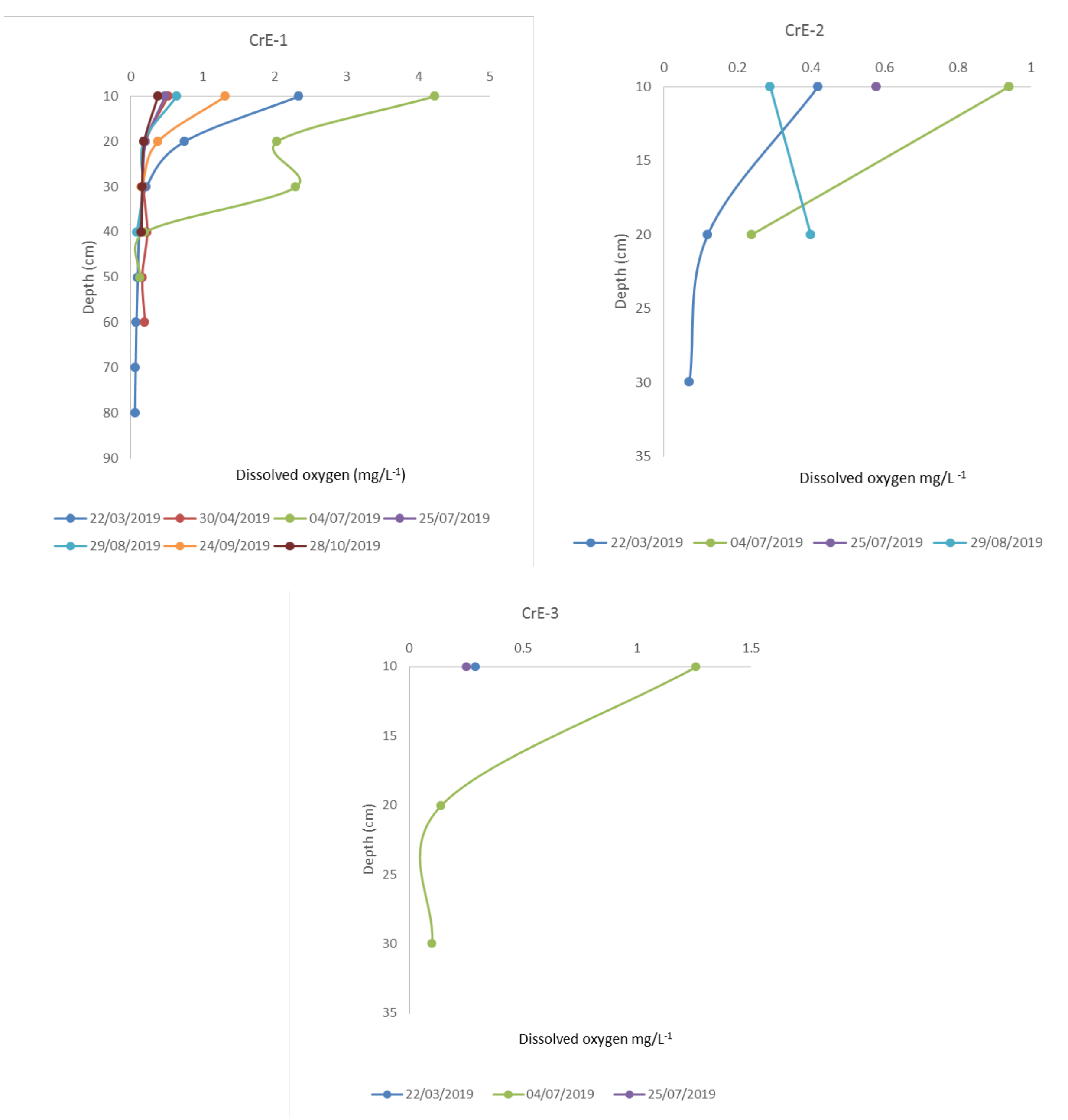

Figure 12. Dissolved oxygen profiles at each sampling point in Crescencio Experimental Canal

pH

The pH fluctuated between 6.5 to 8.5, a range that is considered normal for irrigation water (Jones and Wolf, 1984). It is also within the range dictated by norm NOM-127-SSA1-1994 water for human use. Nevertheless it can be seen that during the rainy season pH values vary a lot more between the studied canals although the same tendencies are observed for all the canals.

	LUC T	LUC B	LUE T	LUE B	CRC T	CRC B	CRE T	CRE B
Marzo	7.18±0.18	6.75±0.26	7.00±0.36	7.04±0.28	7.45±0.10	7.34±0.07	7.58±0.48	7.23±0.43
Abril	7.85±0.43		7.61±1.03		7.57±0.12	7.31±0.28		
Mayo	7.53±0.25	7.16±0.23	7.97±0.46	7.63±	0.28			
Junio	7.36±0.32	7.44±0.16	8.12±0.50	7.60±0.25	8.13±0.55	7.46±0.21	8.82±0.10	7.83±0.32
Agosto	7.16±0.06	6.94±0.05	7.48±0.16	7.08±0.28	7.23±0.15	7.11±0.15		
Septiembre	7.55±0.29	7.61±0.17	8.33±0.13	7.81±0.29	7.87±0.15	7.66±0.21		
Octubre	6.77±0.19	6.58±0.19	7.53±0.25	7.14±0.33	7.55±0.14	7.25±0.19		
Noviembre	7.87±0.45	7.79±0.46	8.53±0.25	8.09±0.40	8.31±0.19	7.87±0.19		

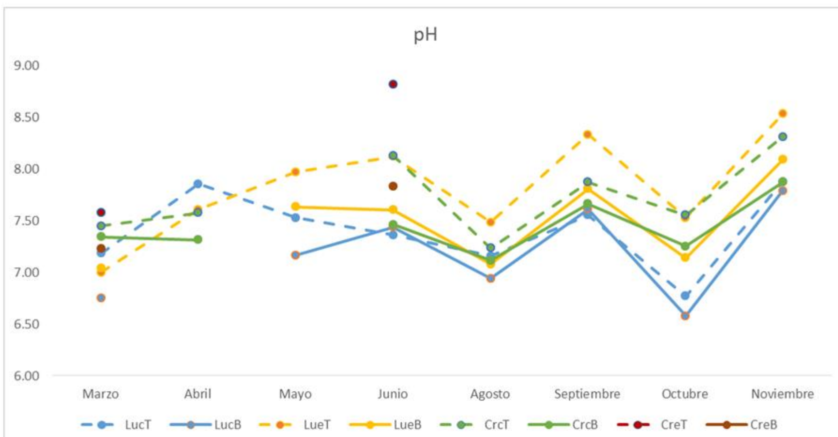

Figure 13. Temporal behaviour of the average pH of the water from the studied canals. (T=Top; B=Bottom)

Conductivity

The conductivity in the water is due to the soluble salts present in it. Problems occurs when there is an excessive concentration of soluble salts in water used for irrigation since it can negatively affects the crops and eventually salinize the soil.

The conductivity in the studied canals had a maximum of 2165 µS, a minimum of 579.33 µS and an average of 1117.35 µS. These values are within the Mexican norm NOM-CCA / 032-ECOL / 1993 with a maximum permissible limit (2.0 dS m^{-1}). Also, the conductivity in the canals is considered within the tolerable range of 750 to 2000 µScm^{-1} for irrigation (James et al., 1982). Only the Lu canals during the first months of the year were slightly over the above mentioned guidelines (> 2000).

	LUC T	LUC B	LUE T	LUE B	CRC T	CRC B	CRE T	CRE B
Marzo	776.33±7.25	868.33±113.09	1967.75±114.32	2165.75±298.96	1649.25±78.29	1604.00±67.02	1550.50±135.93	1713.00±118.67
Abril	644.33±5.03		1483.00±70.68		893.50±75.48	900.50±123.23		
Mayo	769.33±16.86	755.67±21.50	2015.00±265.16	2088.33±170.91				
Junio	591.67±53.82	579.33±34.93	1410.33±67.88	1556.00±70.36	672.75±63.96	816.75±230.71	1025.00±261.82	1066.67±299.00
Agosto	864.00±7.21	897.33±32.93	1402.00±105.40	1463.50±168.39	1310.00±187.82	1396.33±385.21		
Septiembre	868.33±13.80	885.67±23.03	1244.50±237.32	1337.00±287.28	1037.25±39.07	1166.00±265.72		
Octubre	922.33±11.15	948.33±58.71	1414.80±224.33	1511.00±102.59	1104.25±19.03	1301.75±235.08		
Noviembre	730.67±2.52	727.00±7.81	1081.60±167.98	1085.00±158.15	926.75±110.23	1036.25±227.18		

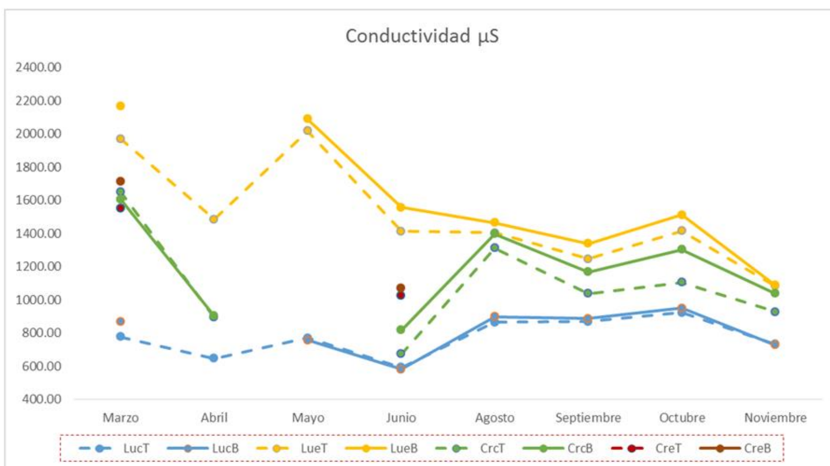

Figure 14. Temporal behaviour of the average conductivity of the water from the studied canals. (T=Top; B=Bottom)

Turbidity

Turbidity is a measurement of suspended particles such as silt, clays and organic matter. The turbidity values obtained varied with a maximum of 14 UNT to 43 UNT with an average of 28 UNT. When comparing the results with NOM-127-SSA1-1994, it can be observed that they exceed the maximum permissible limit (5 UTN). Therefore, the water from the canals in the two sites are classified as highly contaminated. However, with so little depth in the canals, turbidity can be caused by any intervention that produces sediment mobility.

	LUC T	LUE T	CRC T	CRE T
Agosto	18.67±3.21	27.50±8.53	21.25±5.19	
Septiembre	22.00±2.65	16.25±4.50	18.75±5.19	
Octubre	38.00±5.29	35.50±5.26	32.50±9.57	
Noviembre	14.00±0.01	23.80±11.19	43.75±21.34	

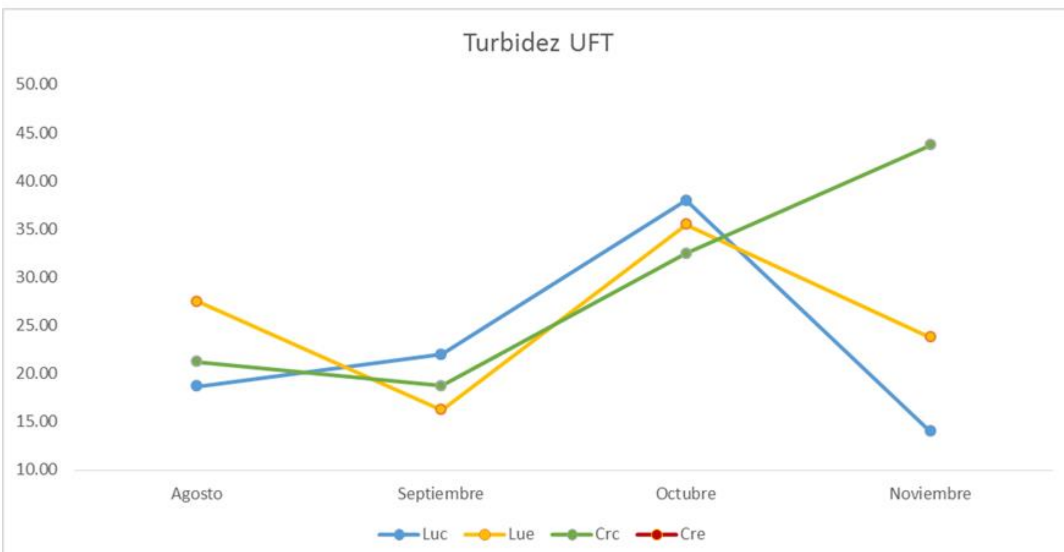

Figure 15. Temporal behaviour of the average turbidity of the water from the studied canals.

LABORATORY PARAMETERS

The parameters that required laboratory analysis were done every two months. The values of the parameters shown in the tables and graphs are the average and standard deviation of the four sections of each sampled canal.

Biological Oxygen Demand-5 day analysis (BOD5)

BOD for all sites has an interesting behaviour throughout the year. BOD decreases dramatically toward the rainy season with the lowest value by the end of it, subsequently increasing again as the dry season starts.

Its concentration is below the maximum permissible limit for irrigation water and public use for natural and artificial reservoirs (NOM-001-SEMARNAT-1996).

	LUC	LUE	CRC	CRE
Mrz-Abr	39.67±0.36	37.66±8.11	31.77±4.27	34.64±1.83
May-Jun	33.90±4.84	23.59±5.75	38.35±5.45	
Jul-Ago	25.11±11.94	29.29±8.78	14.80±7.98	
Ago-Sep	0.76±0.13	5.35±7.99	4.18±3.10	
Oct-Nov	23.21±5.20	26.36±6.06	3.64±2.08	

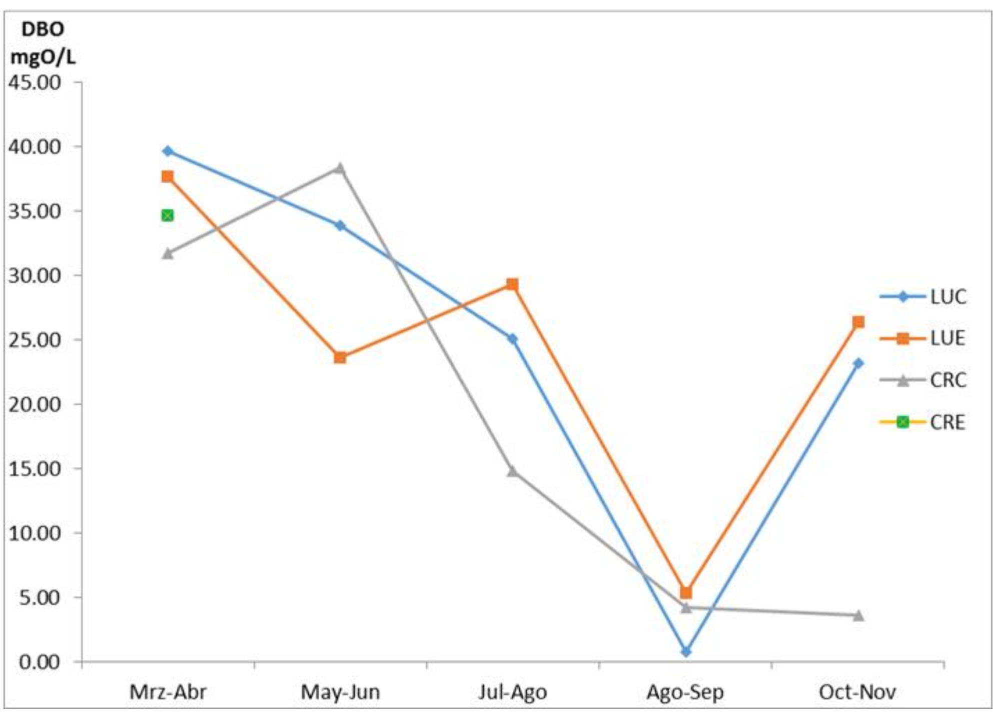

Figure 16. Temporal behaviour of the average BOD5 of the water from the studied canals.

Dissolved Organic Carbon (DOC)

Dissolved organic carbon (DOC mgC / L), is a broad classification used to refer to organic molecules of various origins and composition, such as sugars, fatty acids and alkanes, and complex polymeric molecules within aquatic systems. TOC concentration in the canals is high in general and in LUE canal stays somewhat constant throughout the year. CRE and CRC canals have a peak by the end of the rainy season, although this could be just an isolated episode and not a pattern.

	LUC	LUE	CRC	CRE
Mrz-Abr	17.70±1.74	70.06±0.73	59.56±4.48	70.41±7.97
May-Jun	17.96±10.82	67.34±9.18	45.37±9.75	
Jul-Ago	10.30±6.67	51.63±4.12	38.60±5.96	
Ago-Sep	37.79±9.59	43.29±5.84	97.01±21.22	
Oct-Nov	5.44±1.36	51.58±5.69	38.38±5.10	

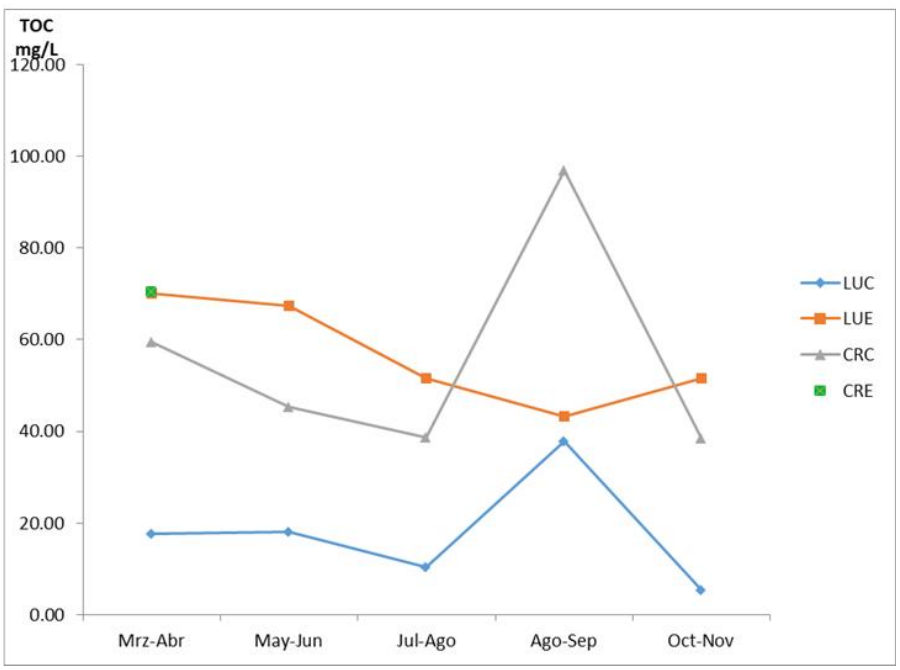

Figure 17. Temporal behaviour of the average DOC of the water from the studied canals.

SUVA

When analysing dissolved organic carbon it is not only important to know its concentration but also to have information about its structure. SUVA can give information about the aromaticity of TOC which in turn can give information about its origin. In this way, it was observed that low SUVA values were found in LUE and CRE, indicating a low aromaticity of DOC, possibly derived from drainage with a higher content of aliphatic compounds such as fatty acids, carbohydrates, etc. In comparison, LUC is more heterogeneous possibly indicating periods of sediment removal, therefore, changes in the aromaticity of the site could be explained by agricultural influence.

	LUC	LUE	CRC	CRE
Mrz-Abr	13.37±3.27	4.10±0.73	5.97±1.02	4.94±1.48
May-Jun	1.34±0.51	2.83±0.22	3.55±0.60	
Jul-Ago	6.21±4.08	3.17±0.47	3.90±0.70	
Ago-Sep	1.98±0.44	2.99±0.43	1.94±0.30	
Oct-Nov	16.87±2.88	2.93±0.21	4.78±0.09	

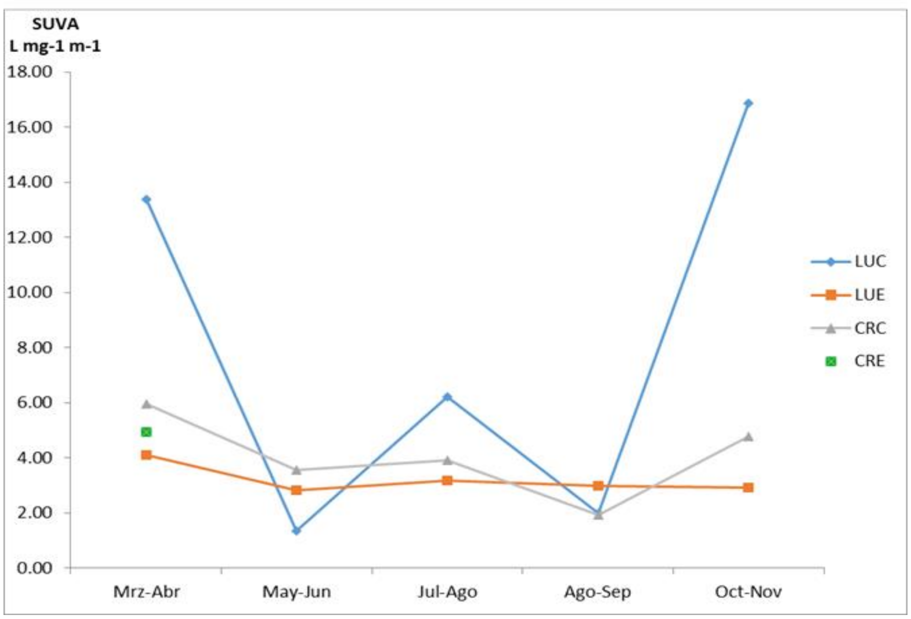

Figure 18. Temporal behaviour of the average SUVA of the water from the studied canals.

Total Suspended Solids (TSS)

The concentration of total suspended solids remains constant throughout the year, having a good to acceptable quality (CONAGUA 2008), it is within the maximum permissible limits for irrigation water (75 mg / L) and public use (40 mg / L) for natural and artificial reservoirs respectively (NOM-001-SEMARNAT-1996). They varied from 66.78 to 10.22, with an average of 50.21, only the LUE canal during the months of May-Jun had an average of 207.83 mg L-1 that may be due to agricultural management and not a seasonal change.

	LUC	LUE	CRC	CRE
Mrz-Abr	66.78±26.92	60.44±28.54	30.83±3.50	66.78±26.92
May-Jun		207.83±113	54.83±25.82	40.39±28.75
Jul-Ago	44.56±4.03	27.17±2.99	25.92±8.50	
Ago-Sep	39.56±29.56	27.93±12.72	21.67±5.57	
Oct-Nov	10.22±3.24	32.67±10.67	45.83±0.69	

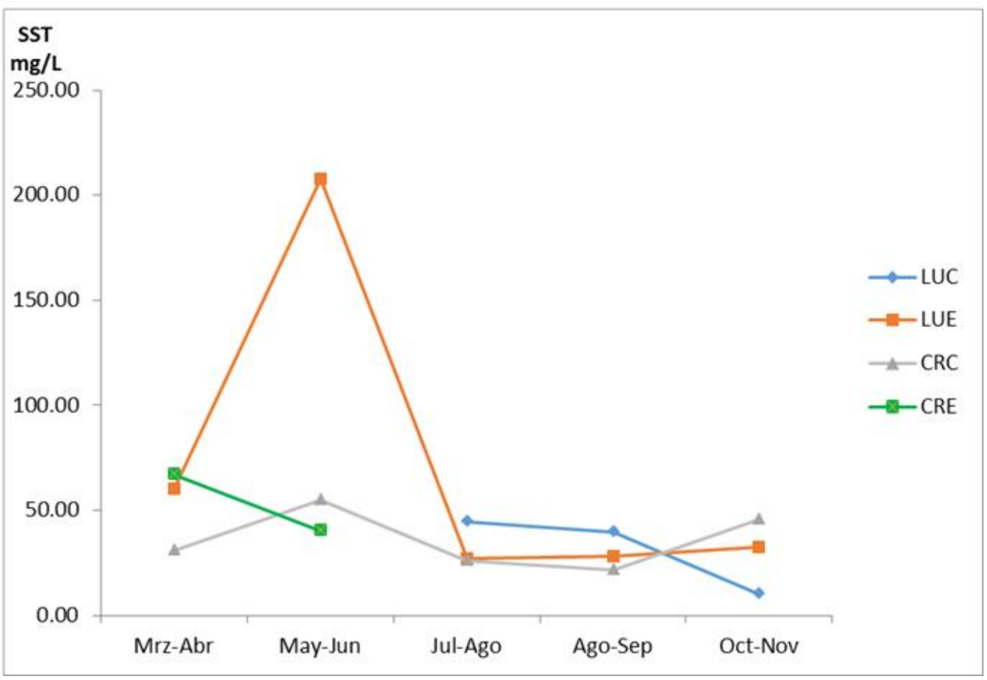

Figure 19. Temporal behaviour of the average TSS of the water from the studied canals.

Sodium (Na)

Canals LUE and CRE remained above the limit set by NOM 147 SSA1-1994 for sodium (200 mg / L) with a tendency to decrease during the rainy season to the maximum established by the NOM compared to the LUC that remained below that concentration indicated by NOM 147 tending to increase from August to November.

	LUC	LUE	CRC	CRE
Mrz-Abr	96.04±9.7	324.74±68.8	267.36±14.3	289.30±29.9
May-Jun	85.70±10.2	302.50±33.8	246.70±31.7	
Jul-Ago	86.40±11.2	201.99±8.9	105.29±10.2	
Ago-Sep	139.65±29.6	199.55±32.2	202.39±41.1	
Oct-Nov	135.92±29.0	195.30±22.7	188.66±38.9	

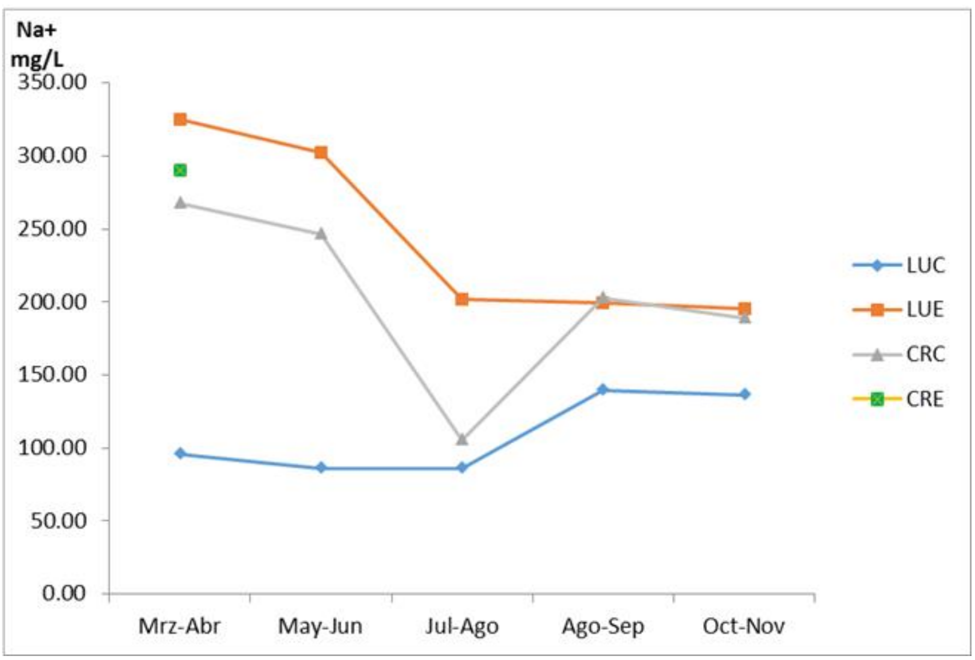

Figure 20. Temporal behaviour of the average Na of the water from the studied canals.

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Nitrogen cycle (Ammonia, Nitrites and Nitrates)

Ammonia is formed from the metabolism of protein and is the major waste product of fish. Ammonia is also formed as uneaten feed or other organic matter decomposing. High concentrations of ammonia in the water make it difficult for fish to eliminate ammonia from their bodies. This build-up of ammonia can cause stress, gill and internal organ damage, and eventually death.

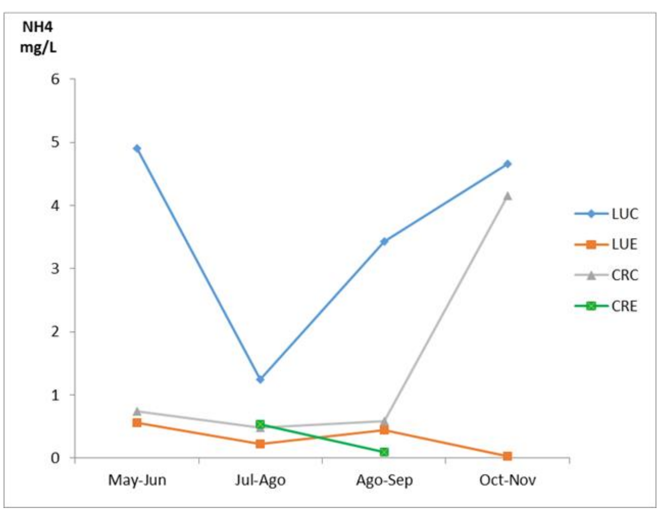
Nitrite is formed by the conversion of ammonia by nitrifying bacteria. Nitrite is toxic to fish because it binds with the hemoglobin in fish's blood to form methemoglobin.

Nitrate is formed from the breakdown of nitrite by nitrifying bacteria. Except in very high concentrations, nitrate is not toxic to most freshwater fish. Nitrate can be absorbed by plants or removed from the water through periodic water changes. In natural systems and some aquarium systems, nitrate is converted to nitrogen gas by denitrifying bacteria.

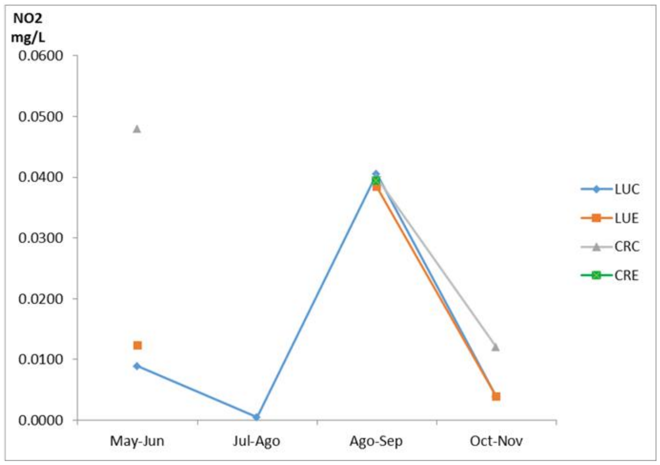
Ammonia is clearly higher in LUC, though during the rainy season its concentration drops dramatically but recuperates in the following months. LUE and CRC sites have similar concentration and almost constant throughout the year except for CRC during the end of the year. Nitrites have a similar and opposite behavior of ammonia in the canals since they can originate from the ammonia; also it can be seen that nitrite concentrations' changes are more intense than ammonia. Nitrate changes throughout the year have the same tendencies in all the studied canals and the concentrations were similar.

Nitrate is formed from the breakdown of nitrite by nitrifying bacteria. Except in very high concentrations, nitrate is not toxic to most freshwater fish. Nitrate can be absorbed by plants or removed from the water through periodic water changes. In natural systems and some aquarium systems, nitrate is converted to nitrogen gas by denitrifying bacteria.

	LUC	LUE	CRC	CRE
May-Jun	4.91±0.11	0.56±0.40	0.74±0.20	
Jul-Ago	1.24±0.55	0.23±0.22	0.48±0.17	0.53±0.22
Ago-Sep	3.43±0.24	0.44±0.28	0.58±0.34	0.09±0.04
Oct-Nov	4.66±0.12	0.03±0.01	4.15±0.64	



	LUC	LUE	CRC	CRE
May-Jun	0.0089±0.003	0.0123±0.004	0.0479±0.003	
Jul-Ago	0.0005±0.005			
Ago-Sep	0.0406±0.003	0.0384±0.002	0.0400±0.002	0.0395±0.001
Oct-Nov	0.0038±0.001	0.0039±0.001	0.0120±0.004	



	LUC	LUE	CRC	CRE
May-Jun	2.16±0.33	2.64±0.74	5.24±0.09	
Jul-Ago	0.35±0.08	0.50±0.21	0.45±0.16	0.61±0.24
Ago-Sep	3.06±0.12	3.07±0.08	3.11±0.14	3.12±0.11
Oct-Nov	2.94±0.57	2.15±0.54	2.30±0.65	

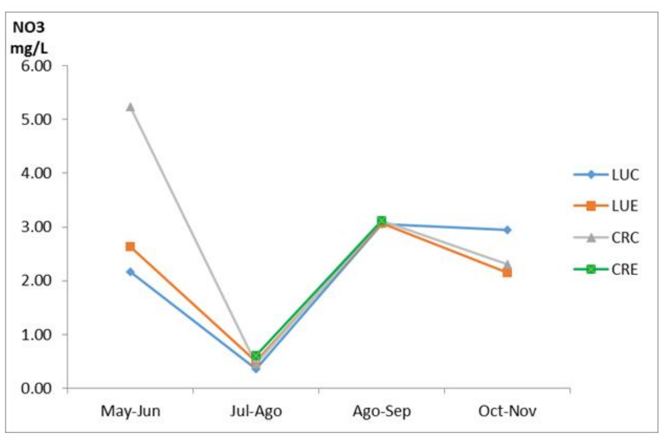


Figure 21. Temporal behaviour of the average of nitrogen species in the water from the studied canals.

Phosphates

Phosphates enter waterways from human and animal waste, phosphorus rich bedrock, laundry, cleaning, industrial effluents, and fertilizer runoff. These phosphates become detrimental when they over fertilize aquatic plants and cause stepped up eutrophication.

Phosphates in the canals show a clear and similar trend with an increase just after the rainy season, probably due to all the runoff that accumulates and causes phytoplankton blooms.

	LUC	LUE	CRC	CRE
May-Jun	5.27±0.40	11.00±0.20	8.65±0.54	
Jul-Ago	6.03±0.06	8.93±0.87	8.13±0.15	16.40±12.02
Ago-Sep	7.53±0.42	7.82±0.29	10.15±0.30	9.40±0.14
Oct-Nov	6.53±0.23	9.38±0.46	10.18±0.38	

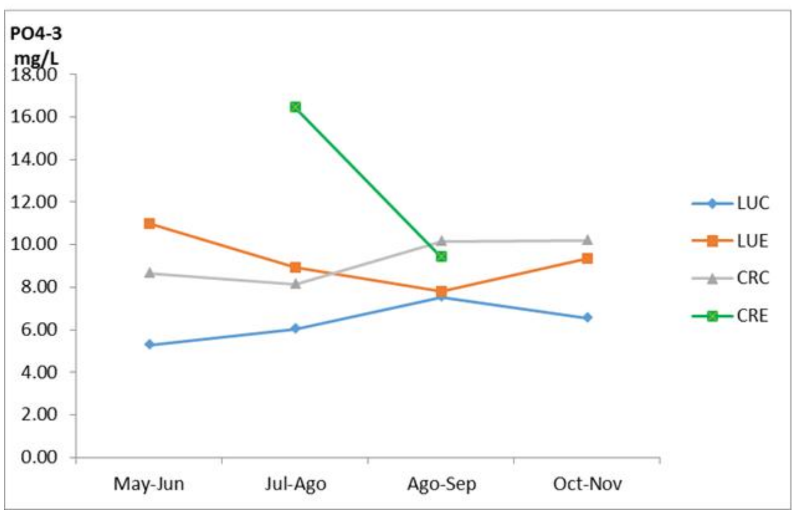


Figure 22. Temporal behaviour of the average of phosphates in the water from the studied canals.

RIPARIAN VEGETATION

Riparian vegetation of canals was monitored using an adaptation of the Riparian Forest Quality Index (RFQ).

Canals studied were classified into control and experimental. Control Canals are open and experimental are closed. The canals belong to the farmers Luis Martínez and Crescencio Hernández. Nomenclature of canals and coordinates, are shown at Table 1.

Canal	X Coordinate	Y Coordinates	Total length (m)
Luis Control Canal			33.2
LuC1	495801	2130426	
LuC2	495797	2130419	
LuC3	495793	2130402	
Luis Experimental Canal			75.8
LuE1	495787	2130384	
LuE2	495783	2130356	
LuE3	495777	2130333	
LuE4	495767	2130329	
LuE5	495765	2130406	
Crescencio Experimental Canal			110.8
CrE1	495604	2130210	
CrE2	495599	2130190	
CrE3	495584	2130126	
CrE4	495569	2130082	
Crescencio Control Canal			118.8
CrC1	495619	2130210	
CrC2	495605	2130155	
CrC3	495594	2130114	
CrC4	495585	2130073	

Table1. Location and length of studied canals

Volunteers helped to gather the following measurements: length of the canals, number of plants with and without flowers; number of helophytes; number of native and non-native trees, area without vegetation, or with non-native trees.

In order to obtain the geomorphology data, the participants measured every 10 meters, the width of the canal; the depth at the middle of the canal and the wall height; the flooding line and shape of the wall at both sides of the canal as depicted in the following diagrams.

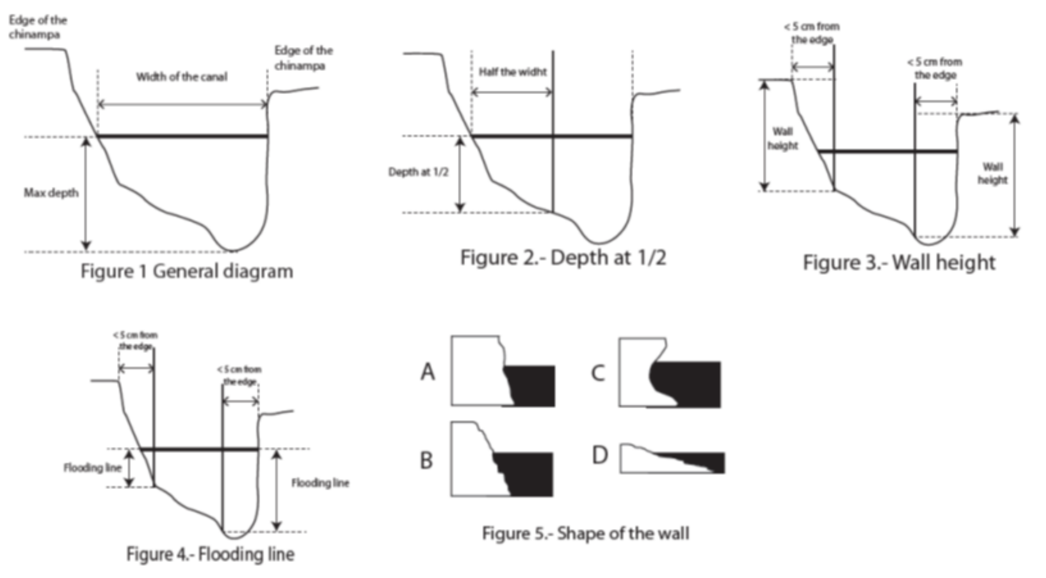


Figure 23. Indications on how to measure the morphometry of the canals.

Physical characterization of canals

The analysis of canal morphometry uses the wall height, the flooding line and depth variation in the four canals studied to do the scores for the RFQ index. The widths of canals were also recorded to characterize the systems.

The following graphs show the average width, wall height and the flooding line for the west side of canals (WH/W) (FL/W), and the wall height and flooding line for the east side of canals (WH/E) (FL/E).

Comparing the experimental canals, at "Luis" the north extreme of canal is wider than in the south (Figure 24), its highest depth is 120 cm (Figure 25), and the walls and flooding line are higher in the west side than in the east side (Figure 26), meaning there is a slope from east to west. This information is helpful in order to know the best macrophytes to be introduced and the best location to the Axolotl experimental cages.

At "Crescencio", experimental canal shows a more regular shape in width (Figure 24), the highest depth is 80 cm (Figure 27). The west wall height is higher at the north entrance of the canal but then it turns the same with the wall height of the east side of the canal. However, the flooding line is lowest than at Luis experimental canal and there were several months that it was completely dry (Figure 28).

Even though both canals are in the same area, the lack of water was more evident in Crescencio's place because the water inputs are different and Crescencio canals depend on handmade waterworks made in the upstream canals.

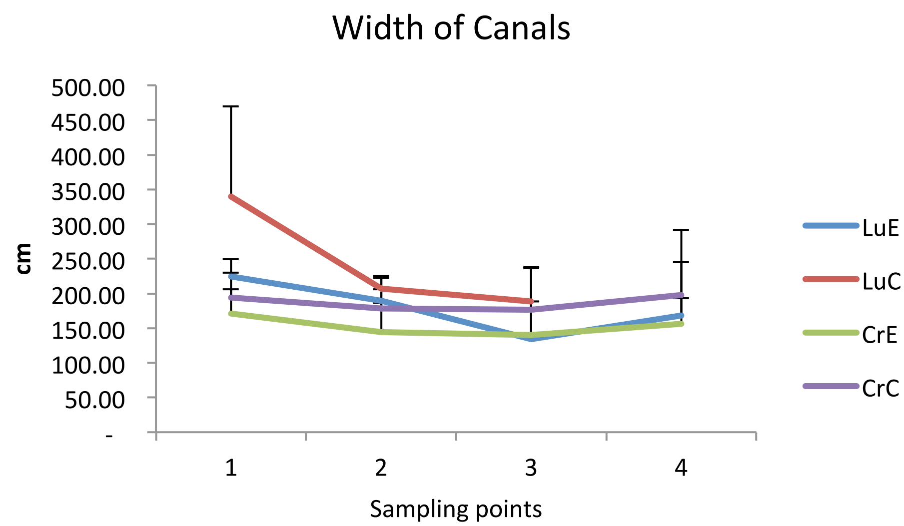


Figure 24. Average width of control and experimental canals at Luis and Crescencio sampling sites. Luis experimental (LuE); Luis control (LuC), Crescencio experimental (CrE) and Crescencio control (CrC)

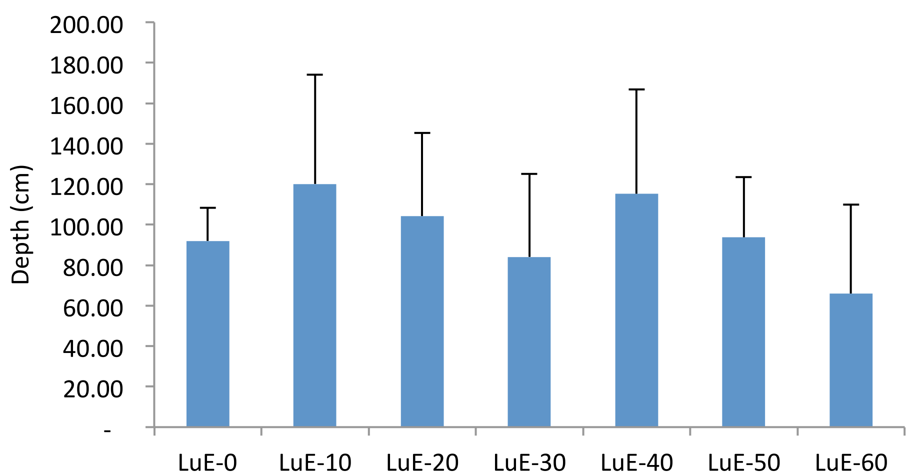


Figure 25. Average depth at Luis experimental canal, each 10 m

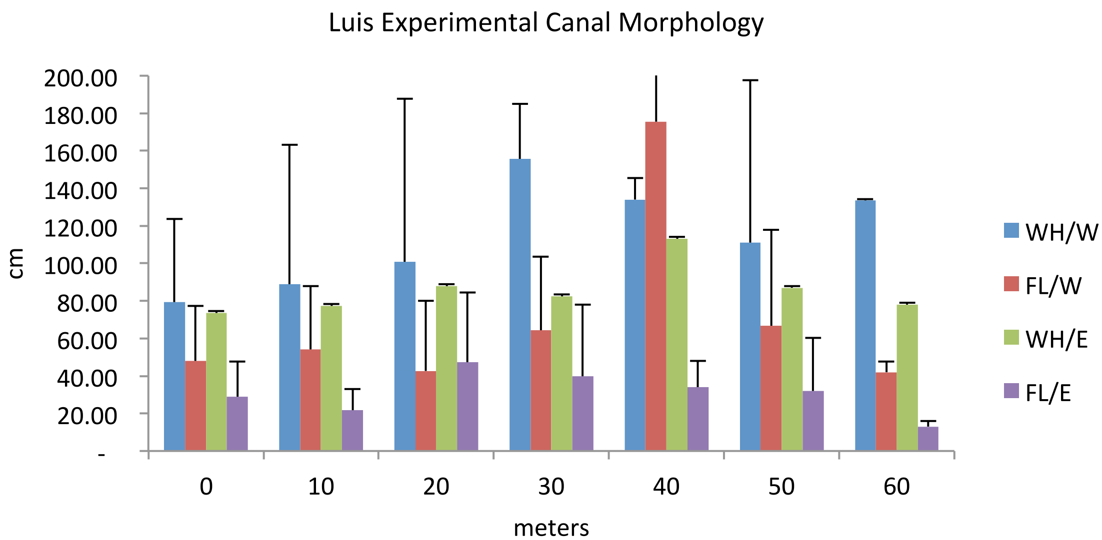


Figure 26. Wall height and flooding line at both sides of the canal

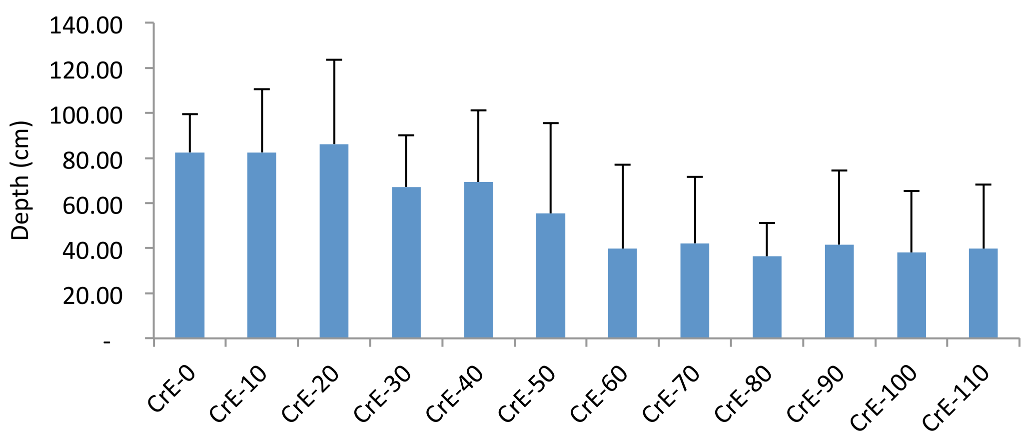


Figure 27 Average depth at Crescencio experimental canal, each 10 m

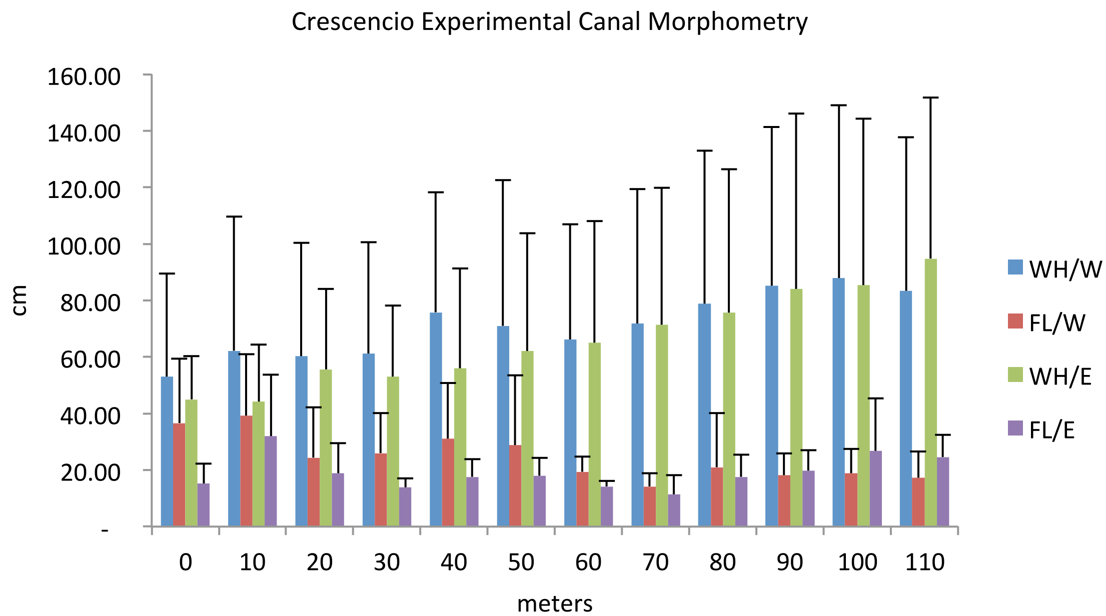


Figure 28. Wall height and flooding line at both sides of the canal

Luis control canal (Figure 29) is open to a lagoon at the northern site, with a depth of 131 cm and to the south it has water input from the urban and greenhouse area. Crescencio control canal is open in both ends; to the north it is connected with the wetland, with 100 cm depth and to the south with the upper stream canals, with 66.5 cm depth (Fig 31).

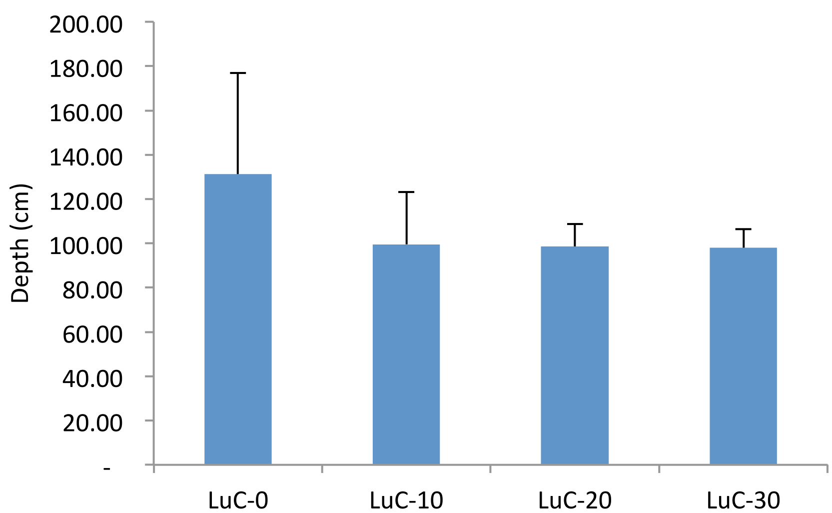


Figure 29. Average depth at Luis Control canal every 10 m

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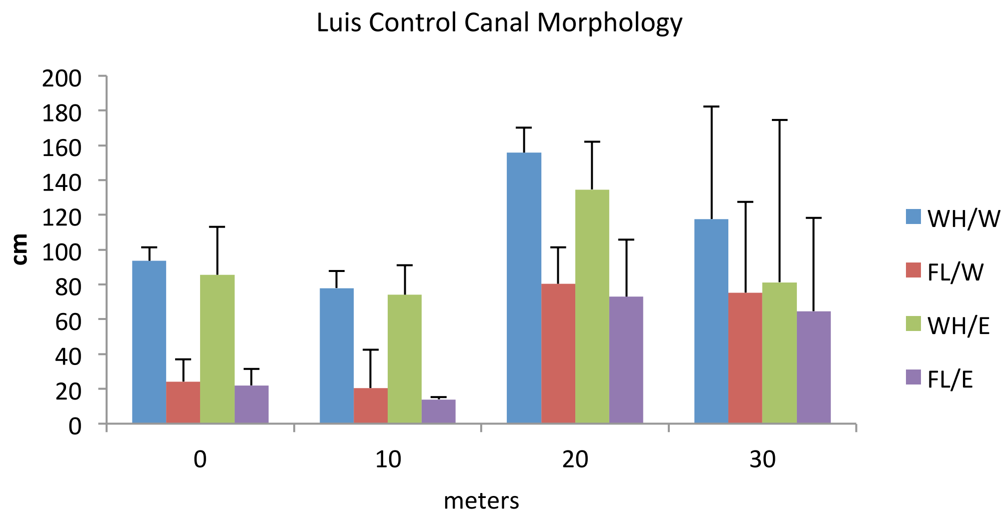

Figure 30. Wall height and flooding line at both sides of the canal

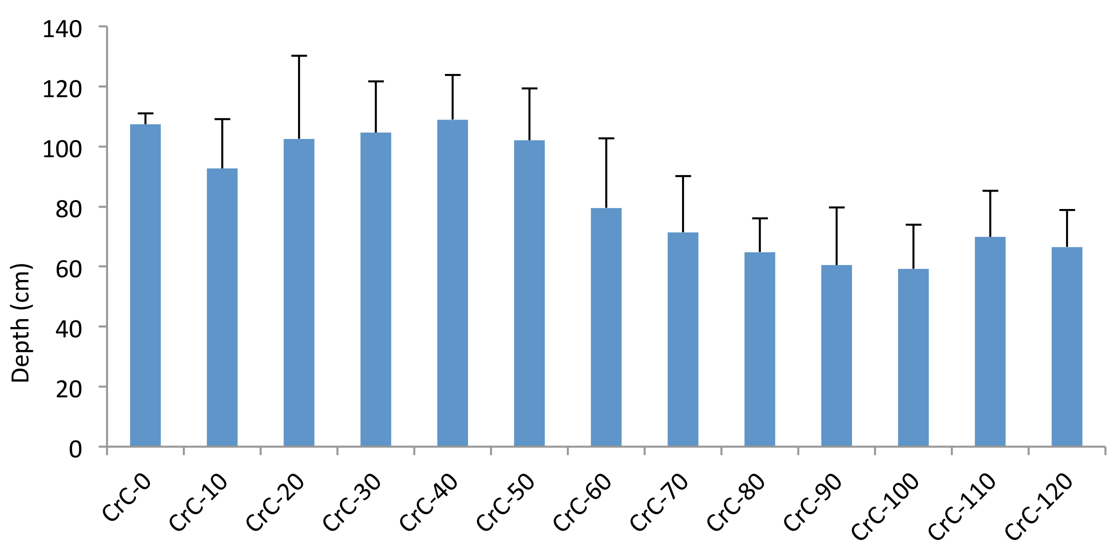

Figure 31. Average depth at Crescencio Control canal, every 10 m

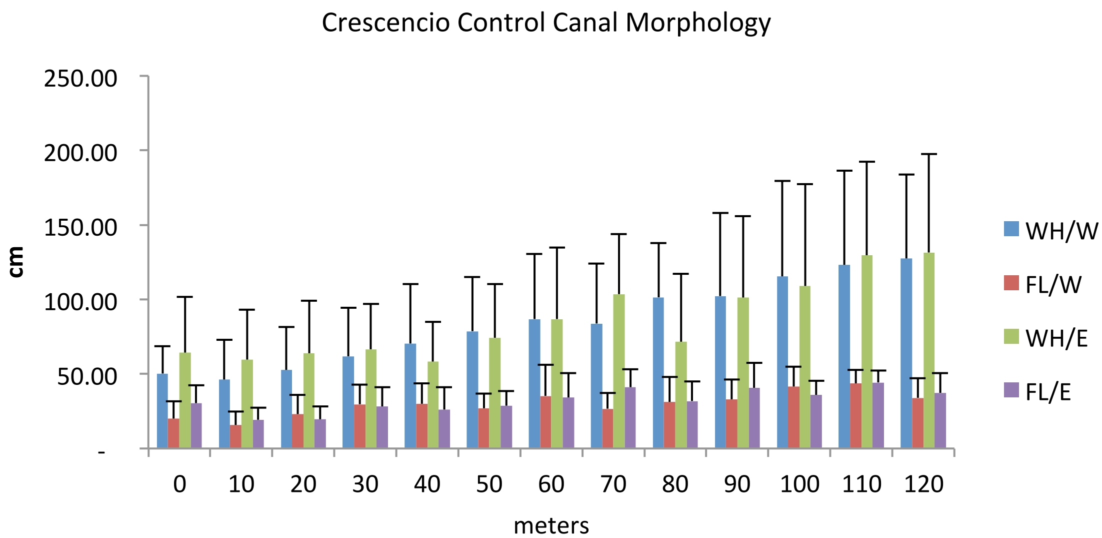

Figure 32. Wall height and flooding line at both sides of the canal

The Luis control canal entrance has a wide opening but low walls and flooding line. Along the rest of the canal, the walls and flooding line are higher and thus sustain more herbaceous and tree vegetation (Figure 30). Crescencio control canal presents the same pattern as Luis, but the walls and the flooding line are lower than Luis control canal (Figure 32).

RFQ INDEX CALCULATION

The RFQ Index, comprises 4 categories:

- **Total Riparian Coverage.** It includes any kind of shrub, bush, helophytes or trees. Grasses were not included because they are constantly removed by the farmers. To do a finest qualification of this category, the connectivity among the riparian and crops is considered important for the preservation of biodiversity.
- **Structure of the vegetation.** It assesses the complexity of the vegetation structure. The initial score is related to the percentage of area covered by trees. The qualification is increased or balanced if there is vegetation under the trees or if helophytes are present in the absence or scarcity of trees.
- **Quality of the vegetation cover.** It mixes the presence of native species, the continuity of vegetation in the edges of the canal, if the vegetation is structured in gallery, presence of buildings or garbage and the geomorphology of the stream.
- **Alteration in the water flow.** Man made alterations to the water flow is one of the main impact to the riparian vegetation. In the wetland assessment, water flow without modifications, palisade fences, stone embankments or rigid structures stopping water flow were evaluated. A further qualification to the main score was considered if the basement of the canal was built with cement or if the structure was doing the function of a dam, retaining completely the water flow.

The graphs show the sum of the scores from each section of the RFQ obtained during the monthly samplings in 2019. The quality of the riparian habitat is assigned according to the following chart:

Riparian habitat in natural conditions	*> 95*
Some disturbance, good quality	*75-90*
Disturbance important, fair quality	*55-70*
Strong alteration, poor quality	*30-50*
Extreme degradation, bad quality	*< 25*

At Crescencio chinampa, the vegetation index classifies the control canal as fair quality, while the experimental is classified as poor quality. The reason is that the experimental canal ran out of water at three of the four sampling points, for almost half of the year, therefore the shrubs and herbaceous plants as well as some small trees, dried up. It is also observed in both graphs of Figure 33 that in April there is a decreasing score in both canals. The riparian vegetation depends mainly on agricultural activities and during April, the farmer decided that since he didn't have the help of a worker to clean it by hand the grass out of the crops to use herbicide on the edges to keep, because.

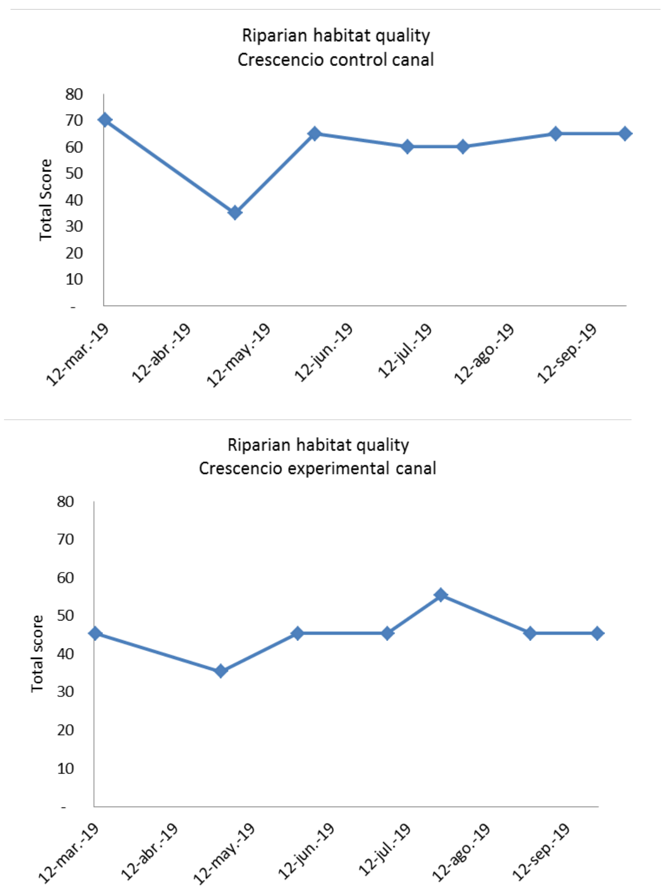

Figure 33. RFQ Index for Crescencio control and experimental canal

At Luis chinampa (Figure 34), the control canal also shows fair quality and the experimental canal poor quality. However, it was observed along the year, that the management of the riparian areas was more sustainable than at Crescencio's, because at the control canal the vegetation remained untouched and at the experimental canal some crops such as cabbage, were planted along the edge. Nevertheless, 30% of one side of the canal lacked of trees and helophytes, decreasing the score in the experimental canal.

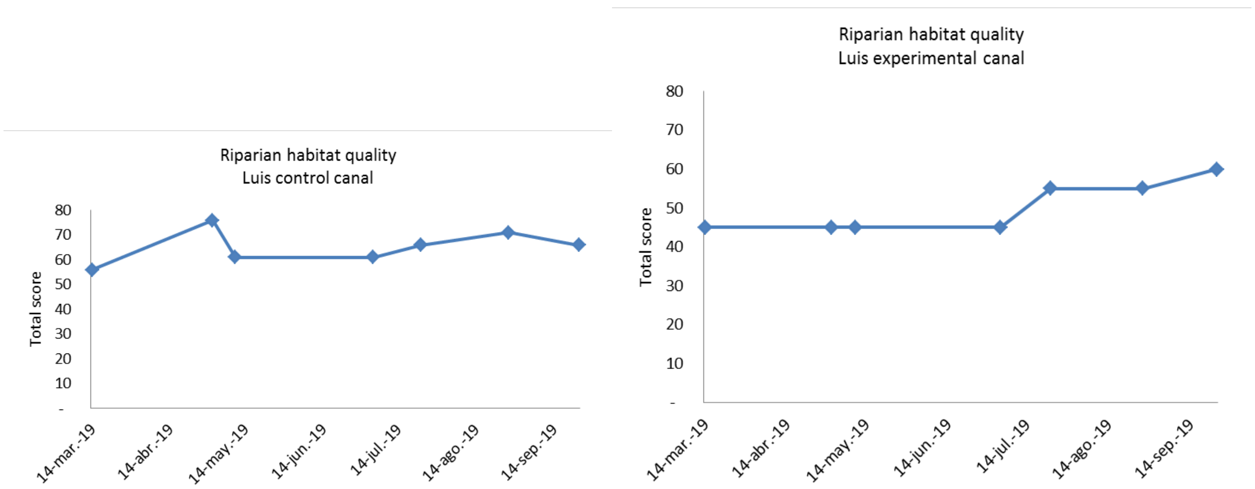

Figure 34. RFQ Index for Luis control and experimental Canal

The riparian vegetation is important for the survival of Axolotls, because it potentially could provide of macroinvertebrate larvae, shadow and feeding and reproductive niches. Getting the cooperation and understanding of the farmers is very important to improve the quality of the riparian vegetation.

Bacteria

San Gregorio canals pollution come mainly from fecal coliforms and *E. coli*, because houses and irregular human settlements inside the Natural Protected Area, drain directly to the canals. There is also presence of pig and beef cattle which also contributes to the pollution.

Even though there is no information on the bacteria harmfulness to Axolotl, since the chinampas are croplands irrigated with water from the canals, it is important to be aware of the impact on human health.

Bacteria sampling was done with a 3M Petrifilm plate and incubated for 24 and 48 hr in a HeraTherm incubator at 35°C. Units Forming Colonies (UFC) were counted and multiplied by 100, in order to accomplish with the normativity unit. Results were transformed in Log 10. According to USEPA, the maximum limit for total coliforms in crop irrigation is 23-240 UFC/100 ml ≈Log10, 2.380 and the maximum limit for *E. coli* is 25-75 UFC/100 ml ≈ 1.875 Log10.

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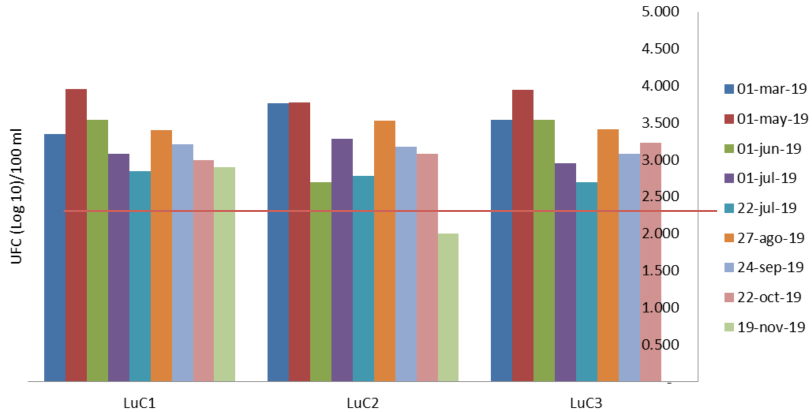
Results indicate that most of the sample analyzed for fecal coliforms and *E. coli*, are over the normativity, as shown in the following graphs.



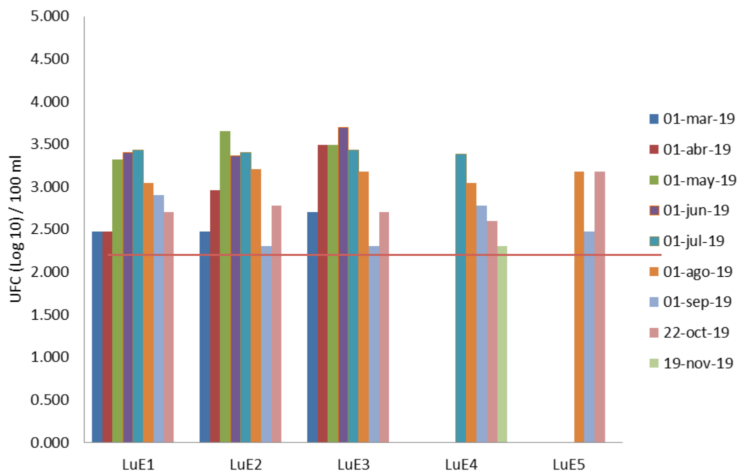
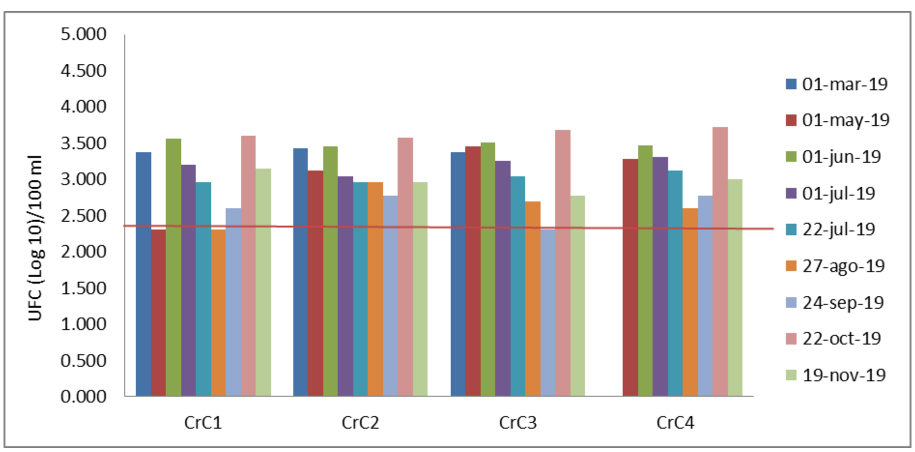


Figure 35. Fecal Coliforms at Luis control and experimental canals



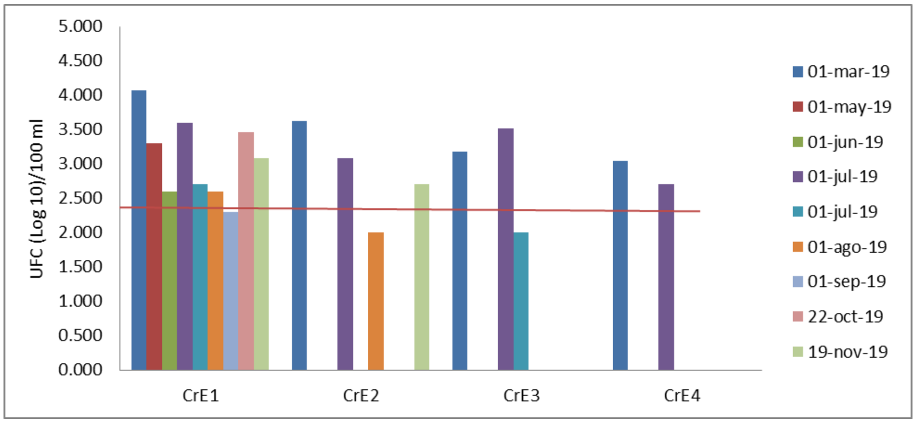


Figure 36. Fecal Coliforms at Crescencio control and experimental canals

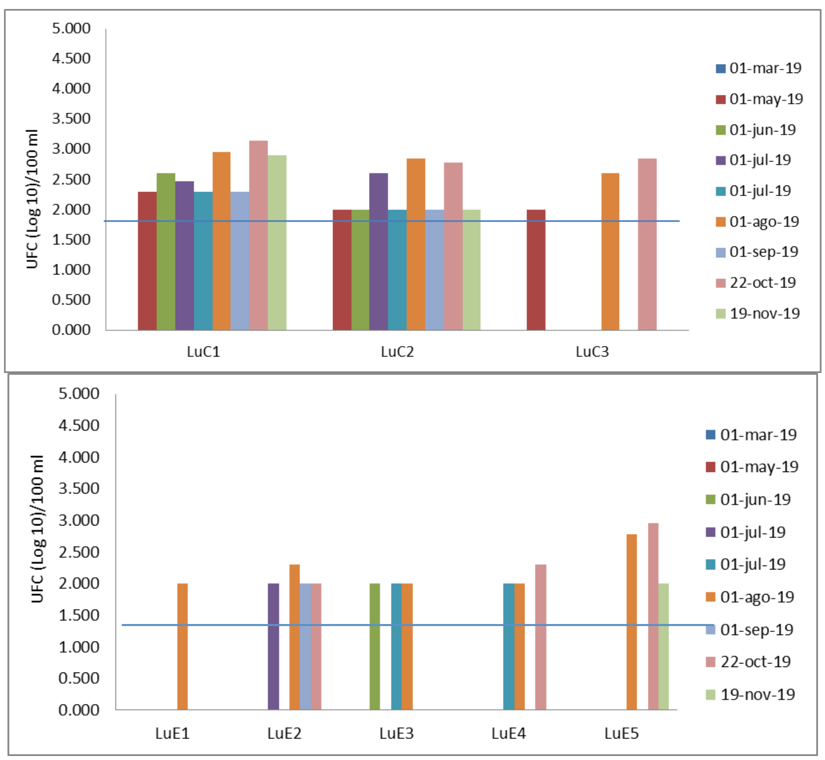


Figure 37. *E. coli* at Luis control and experimental canals

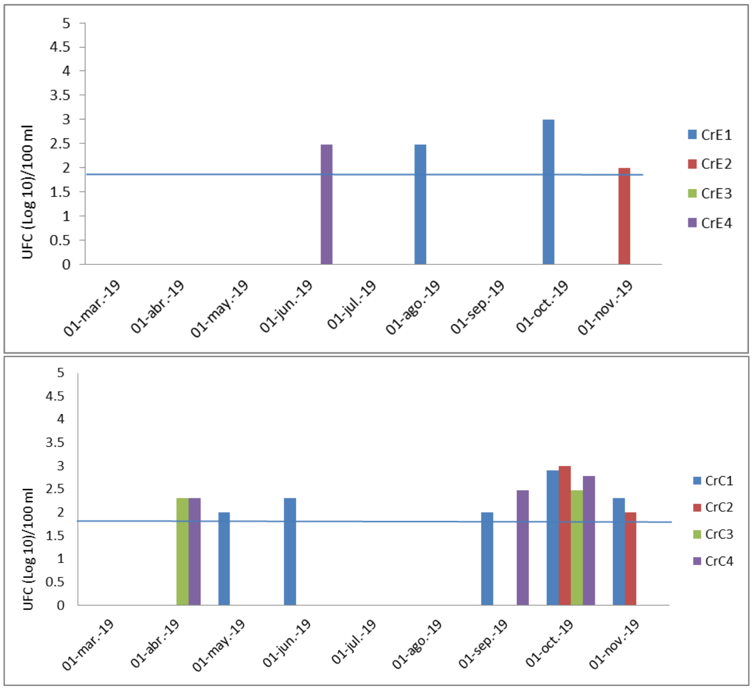


Figure 38. *E. coli* at Crescencio control and experimental canals

PHYTOPLANKTON AND ZOOPLANKTON

The organisms that make up the zooplankton are rotifers, cladocerans, copepods and ostracods mainly, among others (Pace & Orcutt, 1981), the most abundant being the rotifers. This project shows the influence of physicochemical factors on the presence of zooplankton groups, for example, for their survival, growth and reproduction, are needed concentrations above 10 mg / L of dissolved oxygen (Dodson et al., 2009), which is observed with a favorable diversity in the Shannon-Wienner indices where the values are higher for LU canals with a value of 2.99 on average and 2.1 for CR (lowest value); in these two sites we observed on average 23 mg / L of BOD. The pH as well as BOD influences the diversity and abundance of zooplankton, this is reflected in the diversity of sites that on average have a pH of 7.62. The depth also influences the presence and absence of zooplankton, the sites show a depth of 70 cm on average. The transparency of an aquatic system is a factor dependent on the condition of the water in terms of the amount or concentration of matter suspended in the water column. This matter may consist of inorganic particles (minerals and sediments) or organic matter such as microorganisms, algae and decomposing matter, which may be a factor in favor of zooplankton. In the sampling sites we find an average transparency of 32 cm. The relationship between the disturbance and the zooplankton can be used to characterize the water quality of Lake Xochimilco within a short period of time. Therefore, ostrocods can be excellent organisms to use as indicators of water quality. Within some cosmopolitan species we find *Heterocypris incongruens*, species of ostrácod most abundant found in the samples of the present study. As already mentioned, the density was very low due to the type of sampling, usually the ostracods are found in the benthos of the water column. However, the results of ostrocods are also related to the physicochemical factors of water. A physicochemical determinant of water in terms of the presence of ostracods is the transparency that is fixed by the presence of organic or inorganic matter in the environment. By observing in the sites an average transparency of 40 cm and an average depth of 70 cm, we can talk about a recombination within the water column causing a resuspended sediment. This resuspency may be due to several factors, for example the removal of sediments by some species of fish such as carp and tilapia in this case organisms introduced in the canals of Lake Xochimilco (Huser & Bartels, 2015), or by the implement of motor or rowing boats that cause this phenomenon. However, finding these organisms on the surface we observe that they do have a presence within the zooplankton microfauna.

Zooplankton in general can be used as indicator species in aquatic habitats. However, any approach to use as indicators of water quality requires detailed knowledge of its ecology, distribution, biology and habitat preferences (Gannon & Stemberger, 1978). There are three main reasons for acquiring specific knowledge in the ecology of different zooplankton species. First, species differ in habitat requirements; For example, cladocerans species such as *Alona spp*, *Pleuroxus spp* and some ostrocods such as *Heterocypris incongruens* prefer mainly stagnant areas of water bodies. This may be because the species lack structures for swimming, which allows them to walk in stagnant habitats. Second, each species can tolerate different amounts of change in water conditions. Therefore, it is important to know the upper and lower part of the limits of their tolerance to different physicochemical factors, as we have found in this study. For example, in this study we observed several species called "cosmopolitans", for example some rotifers of the genus Brachionus, the ostrácod *H. incongruens*, or the cladocerans of the genus chidoridos, it is known that the "cosmopolitan" species have wide ranges of tolerance for changes in different water variables. This tolerance can have an important adaptation value to increase survival and opportunity under different environmental conditions.

The results obtained in the zooplankton analyzes also show a very marked relationship regarding the sampling month, if we are more specific to the presence or absence of rainfall. In both LU and CR canals (see graph 1 and 2) we observe that from the rainy season the diversity measured with the Shannon-Wienner index (where the measure goes from 0-5 in diversity) shows an increase in the months of rains.

Figure 39 shows that in CR canals the diversity was greater in the months of July, August and September (rainy months), on the other hand May (dry month) shows a very low Shannon-Wienner diversity of zooplankton . The same pattern described in LU canals is observed (Fig 40).

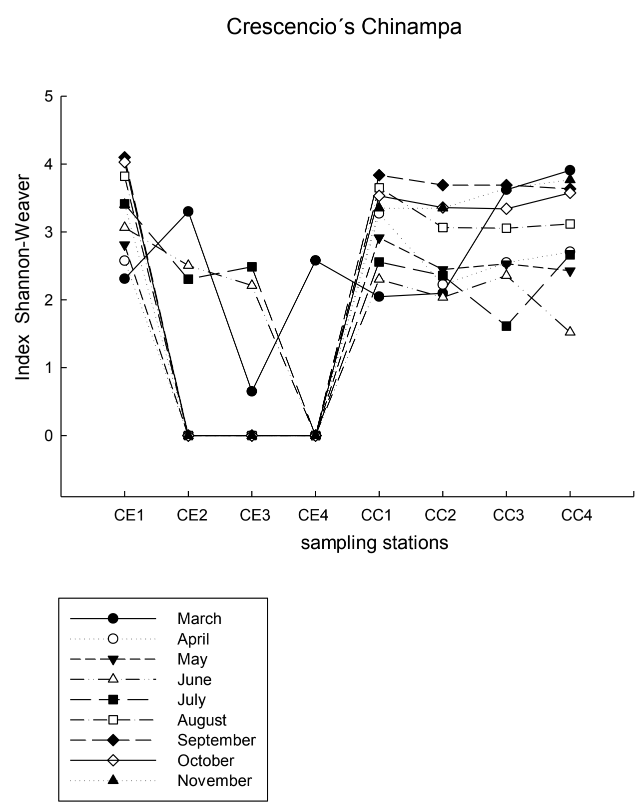


Figure 39. Shannon-Wienner diversity of zooplankton in CR canals.

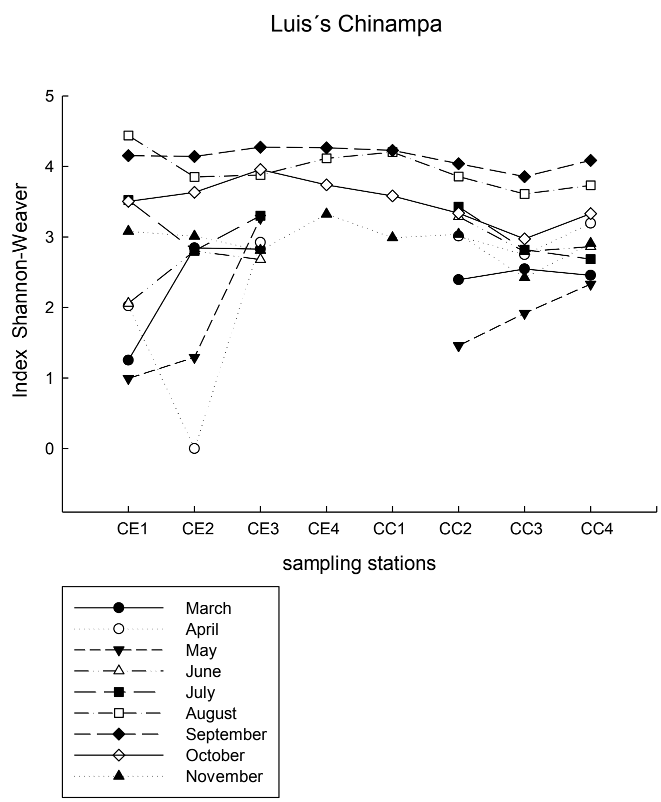


Figure 40. Shannon-Wienner diversity of zooplankton in LU canals.

SHANNON-WIENER DIVERSITY INDEX ANALYSIS IN ZOOPLANKTON COMMUNITIES

The Shannon-Wiener Diversity Index is one of the measures used in this study to try to obtain information from samples in the field. In this study, the index showed effects of habitat quality over a period of one year (2019), mainly in physicochemical and biological factors, effects that indicate pollution effluents. The results of the Shannon-Wiener index combine two quantifiable measures: species richness (# species within community equity) and species abundance (Spellerberg & Fedor, 2003; Keylock, 2005). The organisms were sampled at random, from an "infinitely large" community, in each of the sites (Chinampa de Luis and de Crescencio). Values range from 0 to 4.1296. Since diversity is a logarithmic measure, its relatively asymptotic character decreases the index sensitivity in the range of values near the upper limit as they are in the months of July, August and September at both sites as seen in graphs 41 and 42, while in the months of March to June they showed that sensitivity. The low values are considered an indication of a negative effect on diversity as in the months of March to June (dry) in both sites (graphs 41 and 42). However, it should be noted that a significant difference of 0.05 was determined in an analysis of variance between the Shannon-Wienner index determined in the dry months and the rainy months. A greater diversity of the months from July to September is observed (graphs 41 and 42).

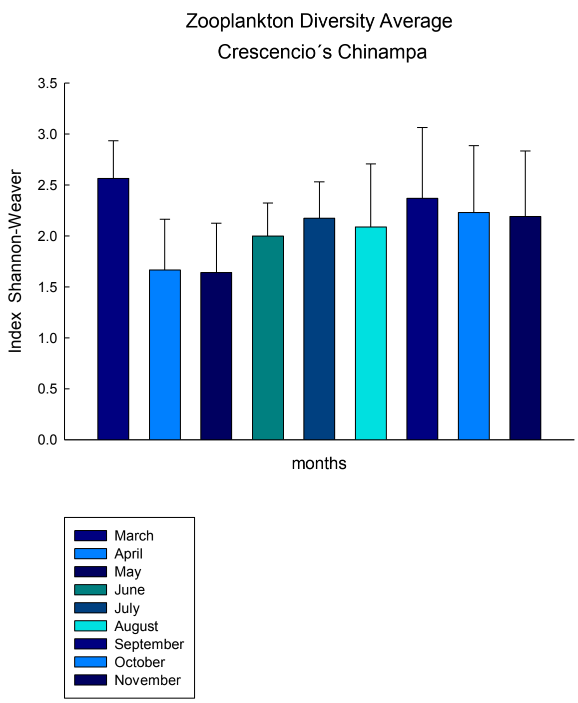


Figure 41. Shannon-Wiener diversity per month in the CR canals.

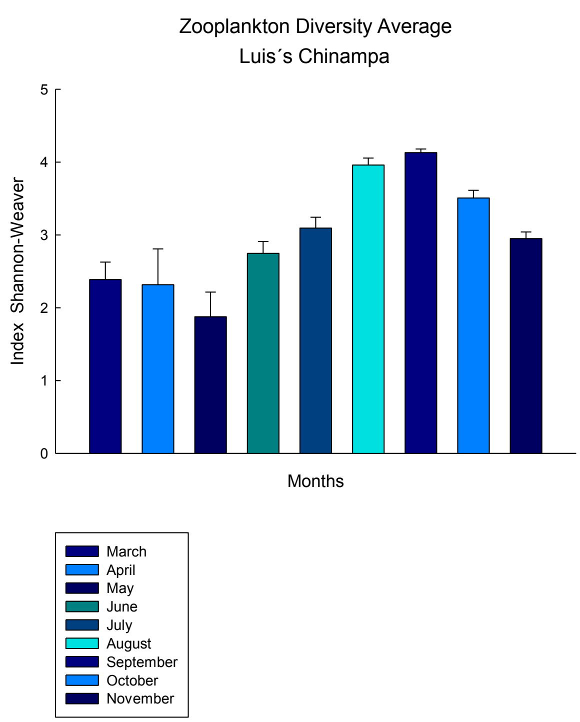


Figure 42. Shannon-Wiener diversity per month in LU canals.

The aquatic macroinvertebrates were collected during March-October 2019, within four canals in San Gregorio Atlapulco two controls (LUC and CRC) and two experimental ones (LUE and CRE), which present 4 points each except the channel LUC which has 3 points. The organisms were collected through a 500 micron entomological beating network, in which 10 repetitions were performed in the water and vegetation, then the vegetation was concentrated in ziploc bags. The samples obtained were cleaned, the organisms were separated, placed in vials and fixed with 70% alcohol for preservation, then they were counted and identified at the gender and family level. Water quality was identified according to the Hilsenhoff biotic index (1988), the values range from 0 (excellent quality) to 10 (very poor quality).

An average of the various sampled points was observed in which water quality and the degree of organic contamination present in the four channels are observed, within the LuC channel, it is mostly poor with a very significant organic contamination with the exception of the LuC1 channel which its quality is almost poor with a significant degree of contamination, for the LuE channel it is also observed that the water quality is similar to that of the control channel, so that the farthest points are those that have a better condition. In general, it can be seen that the CrC and CrE channel has a poor quality with a significant degree of contamination, except for the CrE4 point, where the water quality is regular and a moderate contamination being the most prominent point due to the condition I present during sampling (graph 5).

In graphs 5 and 6 it can be observed in the biotics index of Hilsenhoff (BIH) it shows the degree of contamination and the quality of the water according to the month of sampling, in which April and September thanks to the presence or absence of certain organisms threw a poor quality and a significant contamination being the months with a less critical state, on the other hand, most of the months it was observed that the quality was very poor and the organic pollution at this point became very significant. Within the different points, variations in water quality and organic pollution can be observed even when they were sampled the same month.

Poor water quality and very significant organic pollution predominated in the Cr channel, thus being the month of March, July to September. The CrE4 point is the point with the best parameter, the water quality was very good with possible organic contamination. In April and May I have a regular quality with moderate pollution, while June and October there was a significant organic contamination in terms of water quality was poor (Graph 43).

According to the data obtained, it can be observed that water quality and organic pollution have a lower effect at the farthest points such as the LuC1 (graph 44) or CrE4 (graph 43) point, in which it is not so easy for man to interact in them, according to Figueroa et al. (2007) there is a tendency to decrease water quality by having contact with regions that are easily accessible to man, where they obtained that regions farther from urban areas presented a very good or good quality, while that the closest points the quality was very bad.

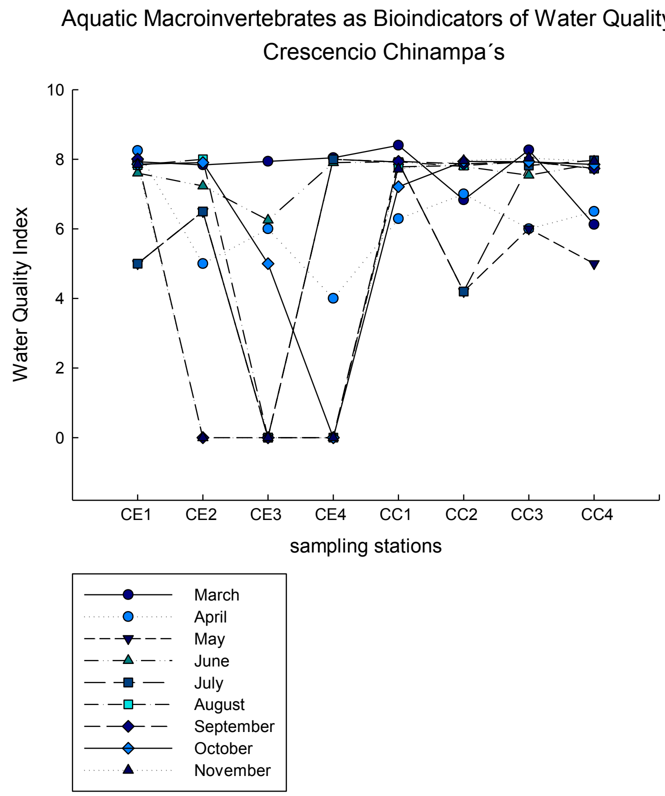


Figure 43 Biotics index of Hilsenhoff (BIH) shows the degree of contamination and water quality during the year for each of the sampling sites in CR canals.

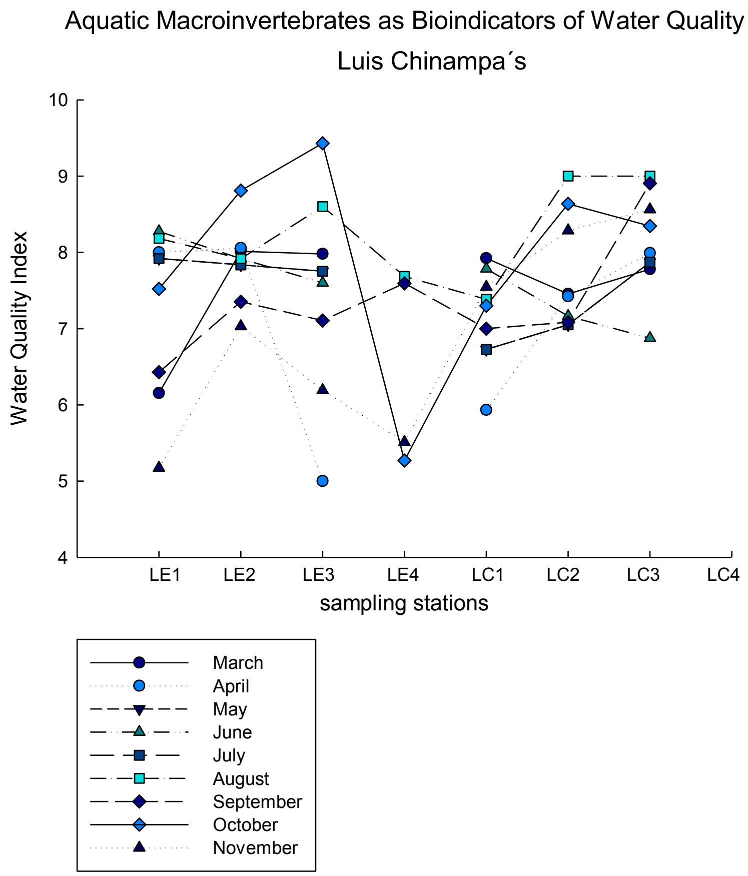


Fig 44. Biotics index of Hilsenhoff (BIH) shows the degree of contamination and water quality during the year for each of the sampling sites in LU canals.

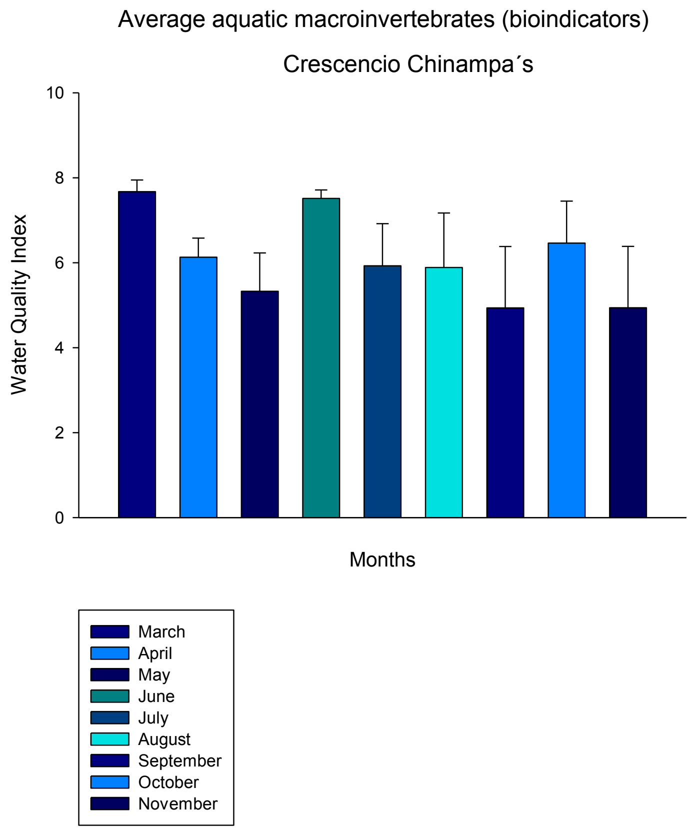


Fig 45 Biotics index of Hilsenhoff (BIH) shows the degree of contamination and water quality during the year in the channels in CR canals.

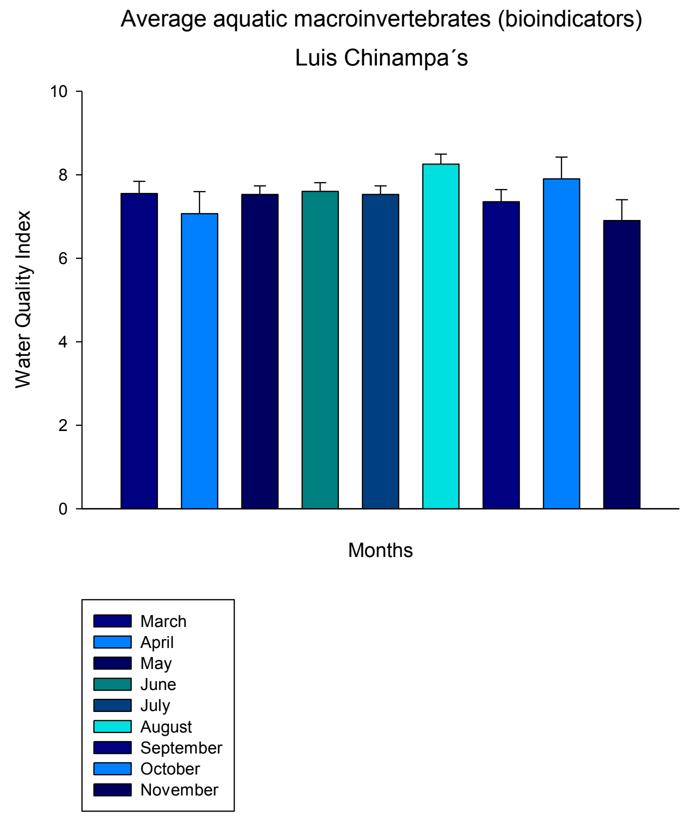


Fig 46 Biotics index of Hilsenhoff (BIH) shows the degree of contamination and water quality during the year in LU canals.

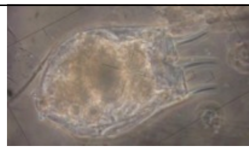
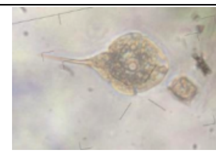
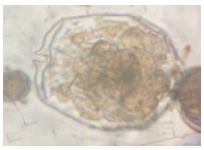
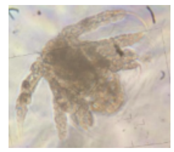
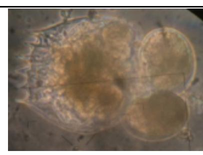
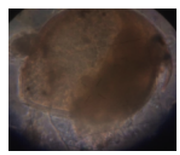
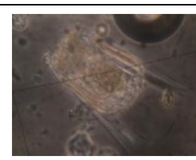
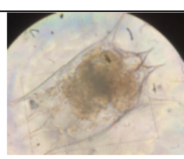
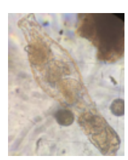
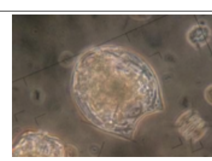
 *Brachiounus budapestinensis*	 *Lecane sp 1.*
 *Brachiounus angularis .*	 Larva nauplio
 *Brachiounus variabilis*	 *Pleuroxus quasidenticulatus.*
 *Keratella americana*	 *Plyathra sp.*
 *Brachionus calyciflorus*	 *Bdelloideo.*
 *Brachionus havanaensis*	 *Lecane luna*

Table 2. Zooplankton species found in the samples of the Chinampas canals of Luis and Crescencio.
Photos taken with the IKON TS100 inverted microscope

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CONCLUSIONS

Our results show that the ecology of the canals is very fragile and surrounding events including seasons of the year have a great impact. Constant and adequate management is imperative for the reintroduction and survival of the axolotl. The most critic parameter to manage is dissolved oxygen, which in turn influences de nitrogen cycle, another important parameter to monitor. As for the riparian vegetation and canal morphology, it is essential to raise awareness with the farmers the importance of the riparian vegetation and canals morphology in order to minimize changes in the canals. The various aquatic macroinvertebrates found within the San Gregorio canals, determine that the water quality is almost poor while the degree of organic contamination is significant, thanks to the parameters established by the biotic Hilsenhoff index. The month of April presented the best conditions for both canals (Lu and Cr), the IBH allows the classification of environmental quality based on the identification of macroinvertebrates.

PROJECT IMPACTS

INCREASING SCIENTIFIC KNOWLEDGE

- **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

- **Peer-reviewed publications**

- **Non-peer reviewed publications:**

- **Books and book chapters**

- **Presentations:**

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MENTORING

- **Graduate students**

Student Name	Graduate Degree	Project Title	Anticipated Year of Completion
Alejandro Escudero	Bachelor's Degree	Distribución espacial del estado trófico de los canales de San Gregorio Atlapulco – Xochimilco, CDMX	March 2020

- **Community outreach**

Name of school, organization, or group	Education level	Participants local or non-local	Details on contributions/ activities
Farmers of San Gregorio Atlapulco	No school to undergraduate	Local	REDES AC continues with the support to the short marketing chain of EcoQuilitl and since last year has been working on the launching of a web page for farmers and consumers, as a following of the proposal of EY Ambassador Program. A new group named Fresco Axayopa was formally launched in Instagram. They also have a brochure, a digital catalog and presentation cards. Redes has launched the Atlapulco Ecotouristic Group. They have received talkings on Federal Normativity and marketing. They already have received visitors, national and from abroad.
Farmers from San Gregorio and San Mateo Xalpa	No school - undergraduate	Local	REDES AC has been working on the project on sustainable water management founded by "Fundación Gonzalo Rio 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. 18 out of 22 rain catchment systems and 8 out of 9 dry bathrooms have been installed. Both systems intend to assist in the mitigation of water pollution due to sewage. Earthwtach is considered a co-founder of this project and as such, it will receive acknowledgement in reports and in the facilities installed.

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PARTNERSHIPS

Partner	Support Type(s)[1]	Years of Association (e.g. 2006-present)
Restauración Ecológica y Desarrollo A.C. (REDESAC)	Funding, logistics, technical support, collaboration	2016- present
Casa de Cultura San Gregorio Atlapulco	Infrastructure for sessions and dining room.	2016 - present

1. Support type options: funding, data, logistics, permits, technical support, collaboration, academic support, cultural support, other (define)

CONTRIBUTIONS TO MANAGEMENT PLANS OR POLICIES

Plan/Policy Name	Type[2]	Level of Impact[3]	New or Existing?	Primary goal of plan/policy[4]	Stage of plan/policy[5]	Description of Contribution

2. Type options: agenda, convention, development plan, management plan, policy, or other (define)
3. Level of impact options: local, regional, national, international
4. Primary goal options: cultural conservation, land conservation, species conservation, natural resource conservation, other
5. Stage of plan/policy options: proposed, in progress, adopted, other (define)

CONSERVING NATURAL AND SOCIOCULTURAL CAPITAL

- **Conservation of taxa**
  - List any focal study species that you did not list in your most recent proposal

Species	Common name	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source
Ambystoma mexicanum	Axolotl / Ajolote	Critically endangered	In danger of extinction	NOM-059-SEMARNAT/2010

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

Species	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source	Description of contribution	Resulting effect[6]

6. Resulting effect options: decreased competition, improved habitat for species, range increased, population increase, improved population structure, increased breeding success, maintained/enhanced genetic diversity, other

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

Habitat type	Habitat significance[7]	Description of contribution	Resulting effect[8]
Wetland canals	Breeding ground	Schooling the management of the canals and farmland to increase water quality	Improved resilience

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

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- **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.

- **Conservation of cultural heritage**

Cultural heritage component[9]	Description of contribution	Resulting effect
Traditional agriculture at Chinampas	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. REDESAC has also worked on the sustainability assessment of the farmers.	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. 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. On March 2020 a farmer's web page will be launched in order to promote the direct sells and visiting the chinampas. 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.

[9]. 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

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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.

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 and their commitment to improve the Xochimilco conservation.

To all EY volunteers for their hard work and enthusiasm during the research activities and skills-based job with farmers.

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

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