MÉXICO
GOBIERNO DE LA REPÚBLICA

SEMARNAT
SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES

IMTA
INSTITUTO MEXICANO DE TECNOLOGÍA DEL AGUA

Holistic Approach to Watershed Management and Freshwater Conservation and Rehabilitation: A Case Study

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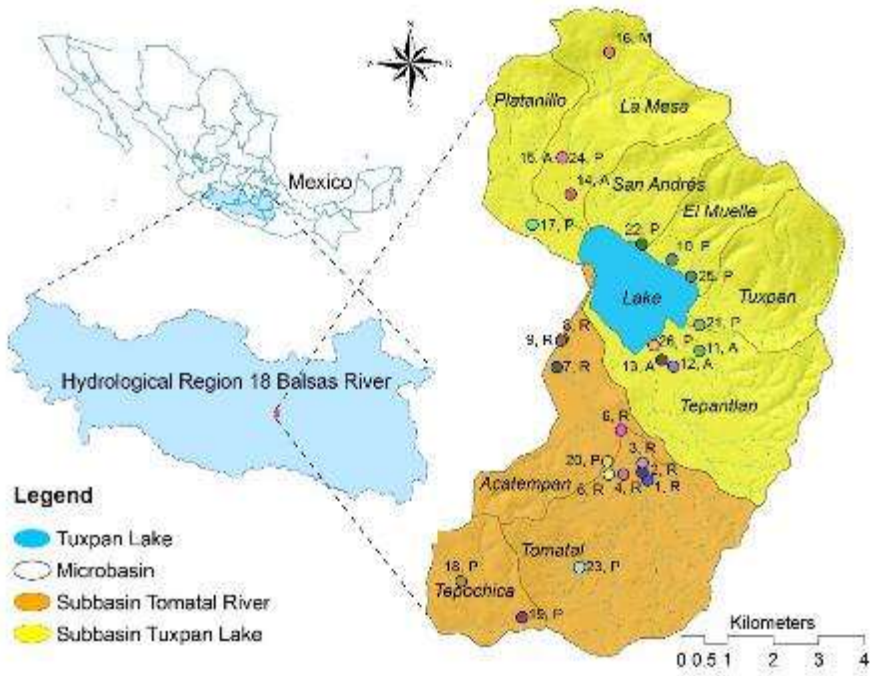
Instituto Mexicano de Tecnología del Agua

2017

Tuxpan Lake



It is located at the geographical coordinates of 18º 20’ 57''N and 99º 28' 43'' W. In the State Guerrero. At an altitude of 757 m.a.s.l.

Population activities, municipal waste, touristic and agricultural activities in the sub-basins of the river Tomatal and Lake Tuxpan, contribute to the contamination of the body of water by altering the habitat and sometimes causing the fish mortality in the lake.

According with Piperno et al. (2007), the lake originated in 3000 BC. The river was diverted to the lake in 49’s to expand the area of cultivation.

OBJECTIVES:

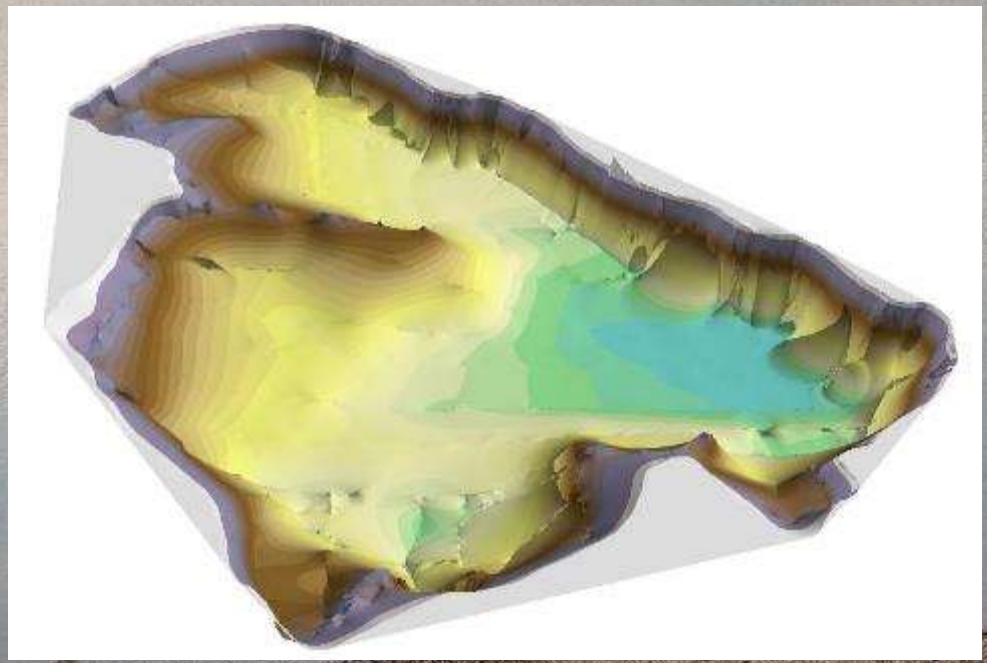
DETERMIN THE CAUSES, LEVELS AND DEGREE OF ENVIRONMENTAL POLLUTION OF THE TUXPAN LAKE.

GENERAT A STRATEGIC PLAN FOR THE MANAGEMENT, CONSERVATION AND RECOVERY OF THE SUBBASINS OF THE TOMATAL RIVER AND THE TUXPAN LAKE.

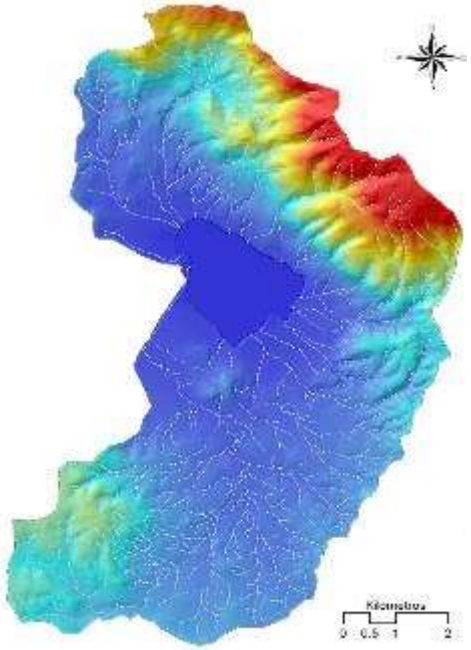
CHARACTERISTICS OF THE TUXPAN LAKE

The lake was formed in a depression of the Earth's crust originated by tectonic movements or tectonic subsidence, with a low porosity in the sediments. Originally it lake was endorreic.

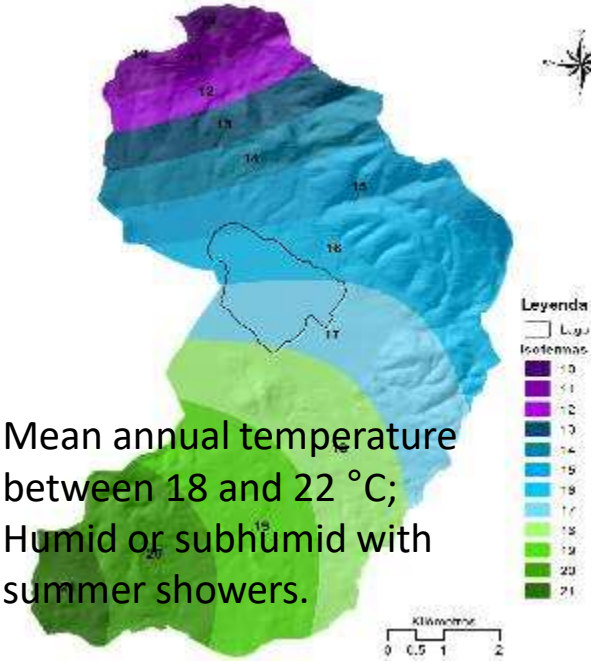
Altitude (m.a.s.l.)	749
Volume (Mm^3)	18.89
Area (km^2)	4.1
Subbasin area (km^2)	70.0
Maximum depth (m)	7.8
Maximum length (km)	2.7
Maximum width (km)	2.2



STUDY AREA



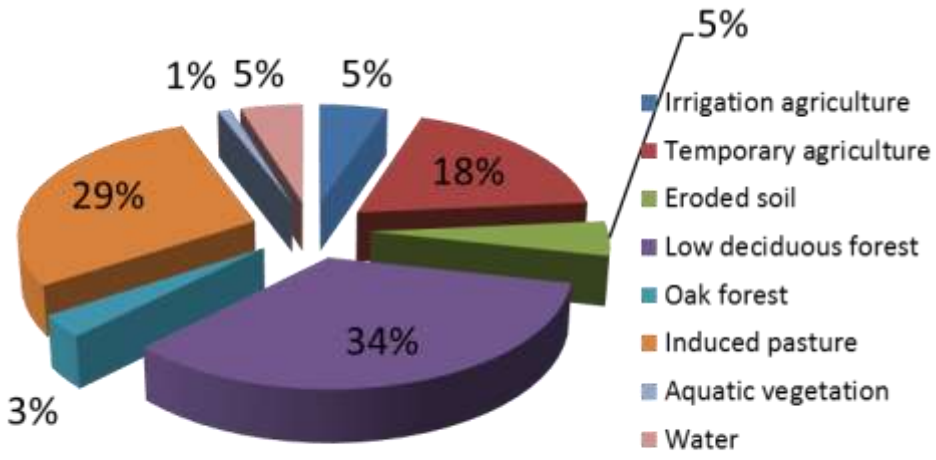
HIDROLOGY and TOPOGRAPHY
(maximum height of 1 731 m)

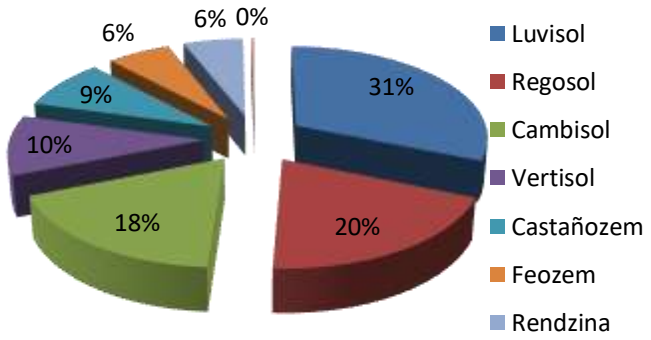


Mean annual temperature between 18 and 22 °C;
Humid or subhumid with summer showers.

Weather: A(C) w1(w) i, rainy tropical

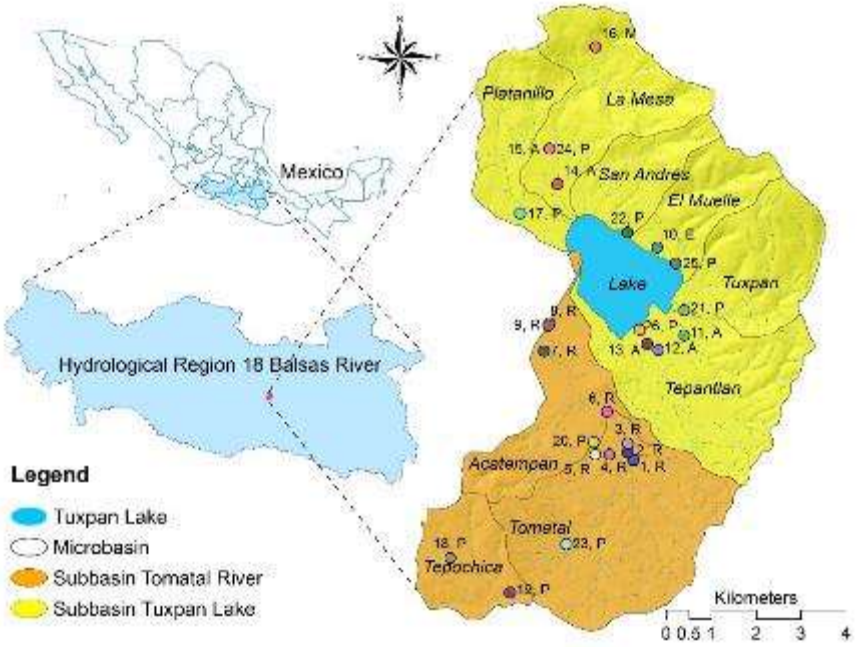
VEGETATION AND LAND USE





EDAFOLOGY

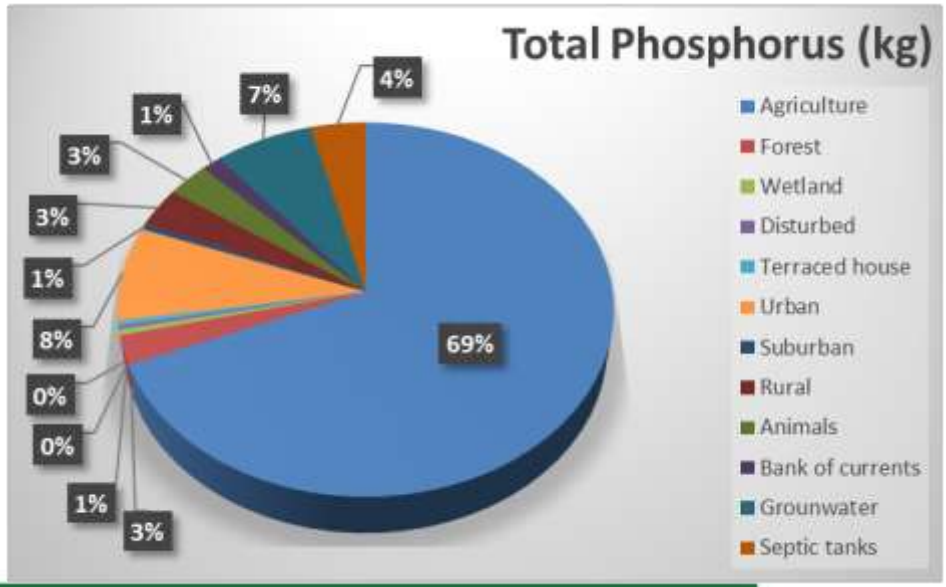
RESULTS

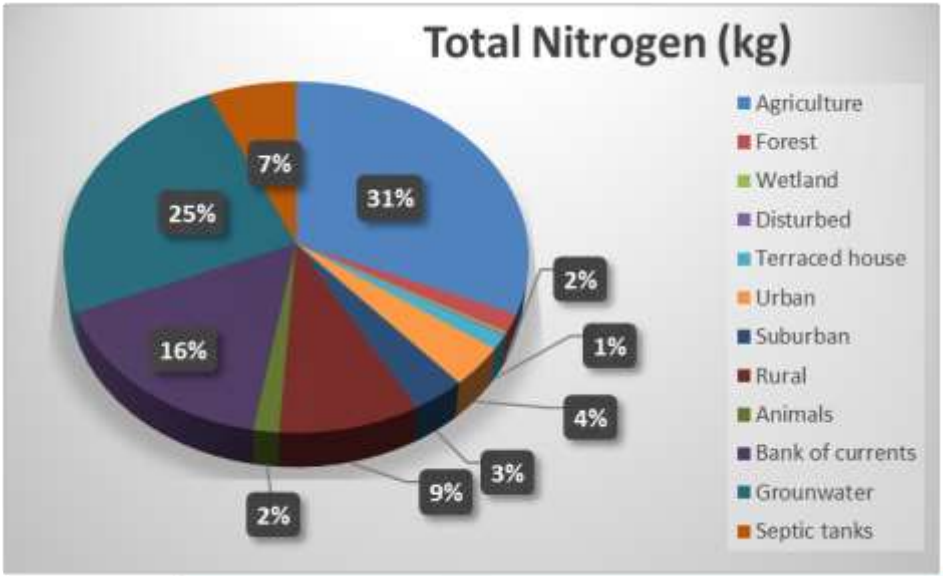


NON-POINT-SOURCE NUTRIENTS

Watershed Simulation Model MapShed data of the 26 stations (river, streams, discharges, storm runoffs, springs, wells, and precipitation)

TS, TSS, TDS, Orho-P and Total P, Organic N, N-NH_4, Total N, N-NO_2 + NO_3; Fecal and total Coliforms and 21 physico-chemecal and biological parameters.





POINT AND NON-POINT-SOURCE NUTRIENTS

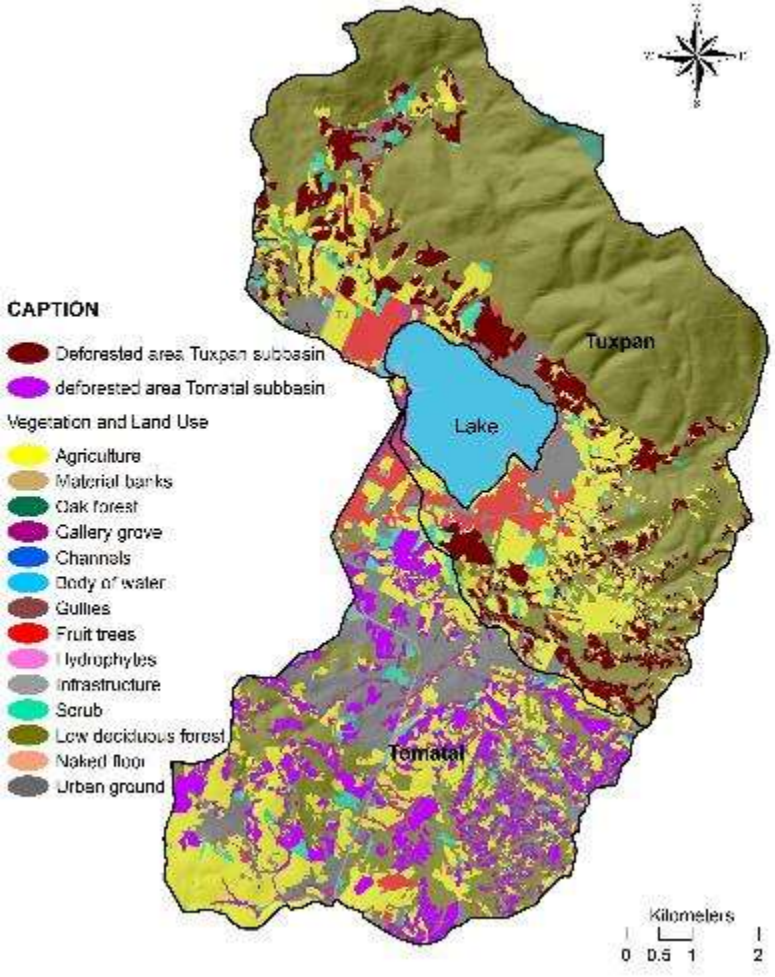
SUBBASIN	NITROGEN (%)	PHOSPHORUS (%)
TOMATAL RIVER	50.14	47.22
TUXPAN LAKE	49.86	52.78

EROSION AND SEDIMENTATION (TOMATAL RIVER)

Month	Precipitation (mm)	Drained Volume (m^3 X 10^3)	Sediments	
			Subbasins (Tons/ha)	River (Tons X 10^3)
JANUARY	0	0	0	0
FEBRUARY	0	0	0	0
MARCH	0	0	0	0
APRIL	4	0	0	0
MAY	40	0	0	0
JUNE	101	88.65	0.599	1.5
JULY	319	414.35	2.944	7.38
AUGUST	125.5	184.18	1.282	3.21
SEPTEMBER	192	173.47	1.146	2.87
OCTOBER	123	198.28	1.482	3.71
NOVEMBER	73	0	0	0
DECEMBER	0	0	0	0
TOTAL	**977.5**	**1 058.90**	**7.453**	**18.7**

Universal Soil Loss Equation (USLE)

Deforestation



Erosion

Sub-basin	Deforested area (ha)	(%)
TOMATAL	**529.561**	**21.05**
TUXPAN	**485.484**	**12.07**

TOMATAL RIVER

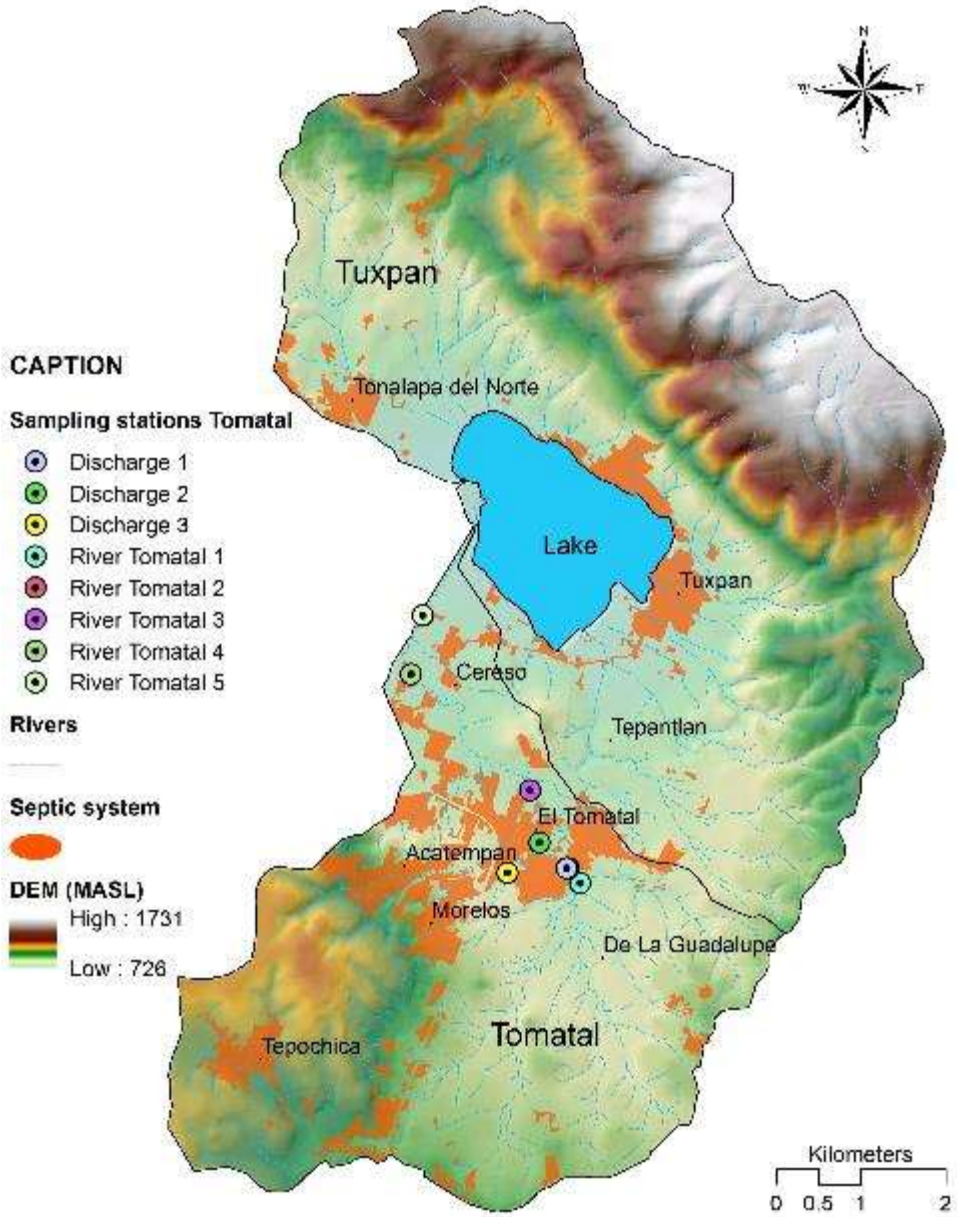
Water Quality

25 physico-chemical and biological variables

5 sampling points in Tomatal River.
3 sampling points of descharges puntual.

Total Suspended Solids, Faecal coliforms Fats and oils, do not comply with water quality for a river neither for natural and artificial reservoirs.

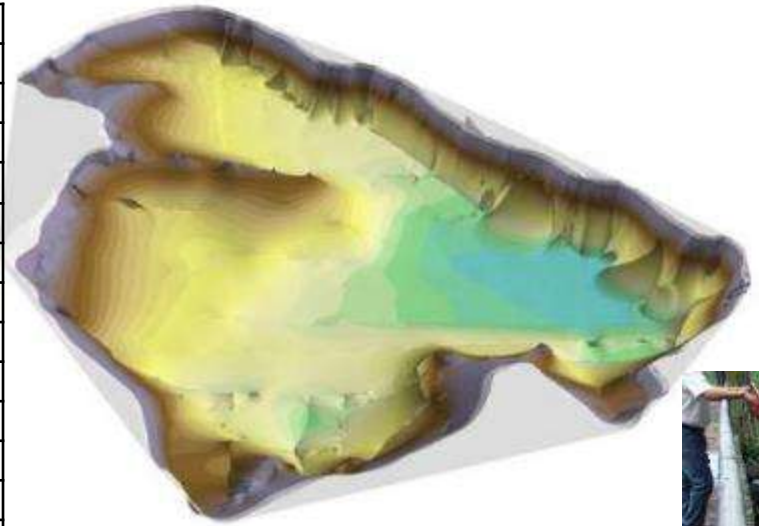
Fecal coliforms of **discharges** did not comply, the ecological criteria (CECA) and NOM-001 (drinking water).



107 years of average lake life

18.7 (Ton X 10^3) average annual sediment through a volume of 24 494.4 X 10^3 of m^3, produce sediment accumulation in the lake.

No.	PARAMETER
1	DEPTH (m)
2	TEMPERATURE (°C)
3	Ph
4	DISOLVED OXIGEN (mg/L)
5	ELECTRIC CONDUCTIVITY (µS/cm)
6	SECCHI DISK (m)
7	TURBIDITY (UTN)
8	TSS (mg/L)
9	TDS (mg/L)
10	COLOR (U Pt-Co)
11	TOTAL ALCALINITY (mg/L)
12	TOTAL HARD (mg/L)
13	CLORUROS (mg/L)
14	SULPHATES (mg/L)
15	BOD_5 (mg/L)
16	QOD (mg/L)
17	SAAM (mg/L)
18	FAT & OIL (mg/L)
19	TOTAL PO_4 (mg/L)
20	TOTAL - P (mg/L)
21	ORGANIC - N (mg/L)
22	N-NH_4 (mg/L)
23	N-NO_3 (mg/L)
24	N-NO_2 (mg/L)
25	Total - N (mg/L)
26	TOTAL COLIFORMS (NMP/100 mL)
27	FECALS COLIFORMS (NMP/100 mL)



Discharge of municipal water and waste

Water quality of the lake

5 sampling points were made,
27 físico-chemical and biological parameters,
During the samplings in rainy and dry season.

PARAMETER	SEASON	E-1	E-2	E-3	E-4	E-5	E-2 Deep
Disolved Oxigen (mg/L)	Rainy	6.64	6.34	6.29	6.43	5.97	**3.75**
	Dry	7.34	6.97	6.40	7.36	7.13	6.22
Turbidity (UTN)	Rainy	24.9	11.7	13	14.6	11.5	**151.73**
	Dry	8.3	9.4	17.3	6.4	5.6	56.0
BOD_5 (mg/L)	Rainy	6.10	2.23	**12.60**	1.18	5.88	**9.30**
	Dry	1.30	2.00	1.50	0.82	1.20	0.98
QOD (mg/L)	Rainy	25.8	22.7	31.3	**54.8**	31.3	33.9
	Dry	31.7	21.9	28	17.4	28	18.1
Total phosphates (mg/L)	Rainy	0.02	0.21	0.12	0.12	0.12	**0.86**
	Dry	0.12	0.15	0.03	0.06	0.06	0.15
Total - P (mg/L)	Rainy	0.009	**0.070**	**0.040**	**0.040**	**0.040**	**0.280**
	Dry	**0.040**	**0.050**	0.010	**0.020**	**0.020**	**0.050**
$N\text{-}NH_3$ (mg/L)	Rainy	**0.239**	**0.159**	**0.324**	**0.226**	**0.239**	**0.336**
	Dry	**0.478**	**0.515**	**0.496**	**0.515**	**0.577**	**0.341**
Fecal coliforms (NMP/100 mL)	Rainy	2.40E+02	9	43	43	28	**1.10E+03**
	Dry	4	2	2	4	2	4

TROPHIC STATUS INDEX (Carlson, 1977)

Parameter	Average
Total phosphorus (mg/L)	0.056
Total Nitrogen (mg/L)	1.493
Secchi Disk (m)	0.59


Ceratium hirundinella

Warm Lakes Index = Mesotrophic - Eutrophic

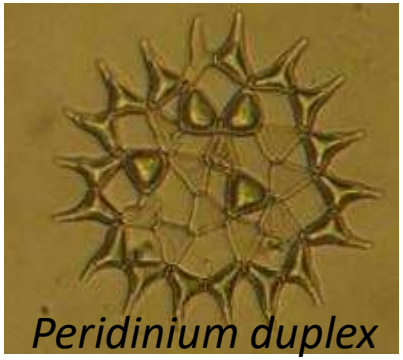
BIOLOGICAL-ALGAE INDICATORS

INDEX (WHO)	E-1	E-2	E-3	E-4	E-5
CRISOFITES	AEM	AEM	AEM	AEL	AEL
CLOROFITES	AEL	AEL	AEL	AEL	
EUTROFICACIÓN					TSI

AEL = a low relative probability of acute effects (health).
AEM = a medium relative probability of acute effects (health).
World Health Organization (WHO)

THIS SPECIES COMPOSITION ARE INDICATOR OF EUTROPHICED LAKES


Peridinium cinctum


Peridinium duplex

CONTAMINATION AND TOXICOLOGY

MICROALGAE

E5	Bacteria	Algae	Cladocera
	Vibrio fischeri	*Selenastrum capricornutum*	*Daphnia magna*
		89.76	

METALS	Pb	Cd	Cu	Cr	Hg	Zn
Sediments (mg/kg)						
E2 - Deep	**12.09**		**23.62**	**12.01**		**64.15**

ORGANIC POLLUTANTS IN SEDIMENT

E2 - Deep Semi-Volatile (Dimetilftalato Dibutilftalato Etil hexil ftalato) & Herbicide (Atrazina)

Damage to the endocrine system of the species and their reproduction


Microcystis

Degradation by turisitc and population activity

Car wash

Agricultural and cattle activities

Summer house

Washing Clothing

The analysis of all this problematic leads us to elaborate

And presence of invasive species.

Hypostomus sp. (Debil fish)

https://www.google.com.mx/search?q=IMAGENES+hypostomus+plecostomus&client=firefox-b&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwiWIeWBidTTAhVDxmMKHRB-C-gQsAQIIg&biw=1920&bih=922

MANAGEMENT PROPOSALS

- STABILIZATION OF GULLIES AND HILLS
- REFORESTATION OF THE SUB-BASIN
- AGROCHEMICALS REPLACEMENT
- CONSTRUCTION OF STONE DAMS
- CLANDESTINE DOWNLOAD CONTROL
- CLEANING AND PREVENTION OF TRASH IN THE TOMATAL RIVER
- RE-PLACEMENT OF THE TOMATAL RIVER
- INVASIVE SPECIES CONTROL
- RELOCATION OF LAUNDRERS
- LAKE WATER QUALITY MONITORING (RIVER AND LAKE)
- CONSTRUCTION OF SEWAGE NETWORK IN THE TOWN OF TUXPAN
- WASTEWATER MANAGEMENT (TREATMENT PLANTS)
- ENVIRONMENTAL EDUCATION PROGRAMS

SEWAGE NETWORK

RIVER RE - PLACEMENT

CLEANING THE RIVER

INVASIVE SPECIES CONTROL

STRATEGIC PLAN

General Actinos	Proyect		Objetive	Federal, state and municipal programs and other sources of funding (foundations) that can contribute to the solution of the problem	Costs (Dollars)
	No.	Proyect name			
A.A.1 Establish programs for the control and closure of clandestine discharges to the River and the Lake.	1	Identification, census and closure of wastewater discharges to the Tomatal River and the Tuxpan Lake.	Identify and account for wastewater discharges to the river Tomatal and Lake Tuxpan, to avoid the contribution of nutrients to the body of water. Incorporate the wastewater discharges from the localities of the Tomatal and Tuxpan to the drainage system or to a marginal collector for later treatment.	APAZU PROSSAPYS	12,500.00
A.A.2 Construction of the sewerage network in the towns of Tomatal and Tuxpan.	2	Executive project for the design of the sewerage network and marginal collectors in the town of Tomatal.	Executive design of the sewerage network of the town of Tomatal (calculations, basic engineering, plans, topography and unit prices of the work).	APAZU PROSSAPYS	53,650.00
	3	Executive project for the design of the sewerage network and marginal collectors in the town of Tuxpan.	Diseño ejecutivo de la red de alcantarillado de la localidad de Tuxpan. Incluye cálculos, ingeniería básica, planos, topografía y precios unitarios del total de obra.	APAZU PROSSAPYS	53,650.00
	4	Construction of the sewage system and marginal collectors in the town of Tomatal.	Construction of the sewerage system and marginal collectors to incorporate the wastewater discharges that are discharged to the Tomatal River to a treatment system. (1,245 inhabitants benefited in the Tomatal).	APAZU PROSSAPYS	450,000.00
	5	Construction of the sewage system and marginal collectors in the town of Tuxpan.	Construction of the sewage system and marginal collectors to incorporate the wastewater discharges that are dumped into the Tomatal River to a treatment system in the town of Tuxpan.	APAZU PROSSAPYS	450,000.00
A.A.3 To construct systems of sewage sanitation with conventional methods.	6	Sewage treatment plants	Build an activated sludge treatment plant that is generated in the basin.	PROTAR	250,000.00
	7	Construction of sewage treatment plant at CERESO.	Treat the wastewater generated into CERESO.	PROTAR	475,000.00

FEDERAL PROGRAMS
CONAGUA
PROTAR
APAZU
PROSSAPYS
PAL
CONAFOR
CONANP
PROCODES
SAGARPA

STATE PROGRAMS
CONAGUA
APAZU
PROSSAPYS
CAPASEG (Water Culture)
SEMAREN
CONACyT-STATE

MUNICIPAL PROGRAMS
CAPAMI
AGENDA AZUL
AGENDA VERDE
AGENDA GRIS
AGENDA BLANCA
PROTEC. BIODIVERSIDAD

OTHERS: Committess, Environmentals Groups, Gonzalo Río Arronte Fundation.

CONCLUSIONS

Disturbances to the environment generated at the Tomatal River were induced by human activities in the early 49's related to the expansion of cultivation areas and the diversion of the natural riverbed towards Lake Tuxpan, which modified the frequency, magnitude and periodicity of river flows and hence the structure and function of the river corridor.

This alteration was compounded by human invasion, which modified the ecological functions of the Tomatal River and by the natural disturbances that also exerted stress on the river corridor.

Therefore, erosion control of hillsides, reforestation of the river corridor with adequate vegetation for regulating the natural flow of the river and its water quality, as well as rechanneling of the river are necessary .

Also, it is necessary control of human invasion of river corridors and associated contamination are necessary, measures to conserve the water quality of the river and avoid the of a great amount of sediment, nutrients, fecal coliforms, and trash into the lake.

THANK YOU

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TUXPAN LAKE

Foto: Leonardo Hernández B.