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Fishes as water quality indicators recorded in Apatlaco and Amacuzac rivers, Morelos, México.

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ABSTRACT

Water conservation is an important goal in ecological studies, that's why this study aimed to assess the quality of water by fish's communities of Amacuzac and Apatlaco rivers at Morelos state, Mexico. Five sampling sites were established: Tepeite, Temixco, Xochitepec and Tlatenchi in Apatlaco River and Amacuzac station in Amacuzac River. National Water Commission (México) criteria were performed to site characterization and assessment of environmental indicators. Six species of fish distributed in three families: Cichlidae, and Poeciliidae Goodeidae were found. In Tepeite site none organisms were captured. At Xochitepec station found the highest richness with four species: *Poecilopsis gracilis, Poecilia sphenops, Xiphophorus helleri* and *Heterandria bimaculata* who tolerate the river pollution conditions. Tlatenchi site has the lowest richness only with two species (*Poecilia gracilis and Poecilopsis sphenops*). In summary, the presence of the fish fauna in Temixco, Xochitepec, Tlatenchi and Amacuzac sites, to be classified as contaminated environments

Keywords: Ichthyofauna. Bioindicators. Pollution.

INTRODUCTION

Water resources in many places have been affected by fastest growth of human population and their activities like agriculture, industry and urbanization, in particular urban downloaded many organic wastes to the rivers, increasing pollution and exerting a negative influence on aquatic ecosystems (Thorne and Williams, 1997).

Aquatic ecosystems contain a large diversity of organisms and their interactions help maintain a balance that translates into a unique biodiversity that is influenced by chemical and physical factors of the environment (Laws 1981). Impacts such as pollution induce changes in community structure in the biological function of aquatic systems in the body affecting their life cycle, growth and reproduction (Bartram and Ballance 1996, Raz-Guzmán 2000). Thus, aquatic organisms may have different levels of tolerance to biotic and abiotic factors, whose resistance to the passage of time allows them to be considered as indicators of pollution (Whiton 1975). These perturbations include temperature, high or low pH, conditions of hypoxia and anoxia, pesticides, heavy metals, hydrocarbons and organic matter, among the most frequent. Groups that are frequently used as bioindicators of contamination are bacteria, algae, invertebrates and fish (Chapman 1996, De la Lanza *et al.* 2000, Aguilar 2005).

The use of fish as indicators based on these substances may accumulate in their tissues, denoting a low survival as well as low tolerance to live in much polluted waters (Lindroth 1949, Whiton 1975). When there is a high diversity and abundance of fish in rivers, lakes and oceans show that the environment is healthy for both fish and for other life forms in water (Aguilar 2005). Unlike high mortality or a high percentage of diseased fish could be caused directly or indirectly by significant levels of contaminants.

Some of the advantages of the use of fish as indicators are that the disturbing environmental factors and these effects are easy to identify as they are manifested as physical abnormalities in the body (Huidobro 2000).

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In Mexico there are few studies where aquatic organisms have been used to assess water quality in rivers or lakes. However, the use of them to know the state of water has been increasing and has been given greater importance to be a complementary tool to the physic and chemical tests. Given the importance of water conservation, this study aimed to assess the quality of water by the communities of fish in Amacuzac and Apatlaco rivers in the State of Morelos.

Study Area

The study was carried out Apatlaco and Amacuzac rivers, which are located within the Basin in the region Amacuzac hydrological No. 18. The basin lies between the parallels 18° 00 'and 19° 15' N and meridians 98° 30 'and 100 ° 00' W (CNA 1999).

The study was conducted during the months of July and October 2002. It established five sampling points: Tepeite, Temixco in Xochitepec region and the Rio Apatlaco in Tlatenchi region and station in the Rio Amacuzac in Amacuzac region (Fig. 1).

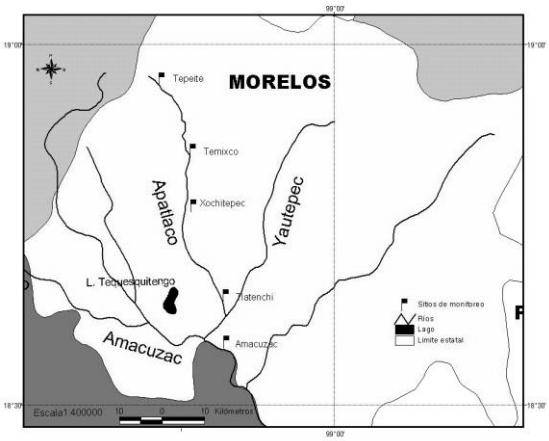

Fig. 1. Geographical location of sampling sites.
Note: Picture map: INEGI 2000.

MATERIALS AND METHODS

Biological material capture

The fish catch was made walking the banks of the water body through a network of spoon, mesh size of 0.5 cm. This type of network was chosen to have high selectivity in the capture of small sizes associated with the banks.

Fixation and conservation of fish

All the collected biological material was cleaned of sediment and organic matter. For conservation and subsequent identification, organisms are placed in containers with formalin (10%) previously labeled with date, time, season, collectors, village, town and fishing gear. For permanent preservation of fish, there were placed on a tray emptied and washed with tap water to remove excess formalin. After this washer, the fishes were placed in glass containers with 70% alcohol to prevent dehydration (De la Lanza and Hernandez 2003).

Identification of fish

The observation and photography of bodies were made with a SZX12 Olympus stereoscopic microscope equipped digital camera. All organisms were photographed on Live Food Laboratory of the Universidad Autonoma Metropolitana-Xochimilco (UAM-X), to start a photographic collection of the species found in the area.

The fish identification was carried out in the Ichthyology Laboratory of the Biology Institute of the National Autonomous University of Mexico with the taxonomic keys of Alvarez (1970) and Meyer *et al.* (1985).

Data analysis

To estimate the abundance of the species of each taxa, the number of organisms per species found (N) were account (Brower and Zar 1977). Also was made a data base with the presence and abundance indicators from each sample (Fuentes and Gaspar 1981).

Characterization of the sampling site

The characterization of the collection sites was performed using observations of the environment and the information was summarized according to the criteria established by CNA (2002).

Environmental indicators

The assessment of water quality aid was supplemented with defined environmental indicators

CNA (2002), giving only two possible outcomes in each comparison for each of the variables: positive, when the sum value does not exceed the criterion value and negative when it exceeds the criterion value. The variables considered were estimated under Mexican Official Standards: for fecal coliform (NMX-AA-42-1987) for phosphate (NMX-AA-029-201), for nitrate (NMX-AA-079-2001) for suspended solids Total (NMX-AA-034-2001), specific conductivity (NMX-AA-093-2000) for dissolved oxygen (NMX-AA-012-2001), biochemical oxygen demand (NMX-AA-028-2001) and ammonia nitrogen (NMX-AA-026-2001).

RESULTS

Ichthyofauna

Six species of fishes were collected in both samples, belonging to the families Cichlidae, and Poeciliidae and Goodeidae. The family Goodeidae was the most frequent (Table 1). The species recorded were: *Oreochromis aureus*, *Ilyodon* sp. *Poecilopsis gracilis*, *Poecilia sphenops*, *Xiphophorus helleri* and *Heterandria bimaculata* (Fig. 2).

At Temixco and Tepeite stations, were not recorded the presence of any species of fishes. Meanwhile, Xochitepec station registers only four species of the family Poecilidae during the month of July. Tlatenchi station shows only with two species of Poecilidae family more abundance that Xochitepec station (Table 1). In Amacuzac station were captured only two species of Poecilidae family with better abundance and only few organisms of Goodeidae and Cichlidae families.

Characterization of the sampling site

In Table 2 are recorded the observations of habitat during the months of July and October. On the site there were lower Tepeite environmental changes such as abundant vegetation in all strata, with the tree one of the most prevalent, as well as the presence of aquatic organisms was very evident (insect larvae and eggs of amphibians). Temixco and Tlatenchi habitat sites were similar in the presence of human settlements and activities, direct sewage discharges, odor generated by the water, bubbles and the presence of fauna associated with urbanization (cats, rats and dogs). The Temixco site submitted without riparian vegetation and aquatic flora, while Tlatenchi was the contrary. Abundant grasses recorded in Xochitepec site even came to be immersed in the river banks, human settlements were scarcer than at the stations mentioned above. The Amacuzac site show abundant vegetation and is it important to mention that the rivers Apatlaco, Yautepec and Cuautla, so that the stream was higher than in other sites (Table 2), causing the entrainment of solid waste in both margins.

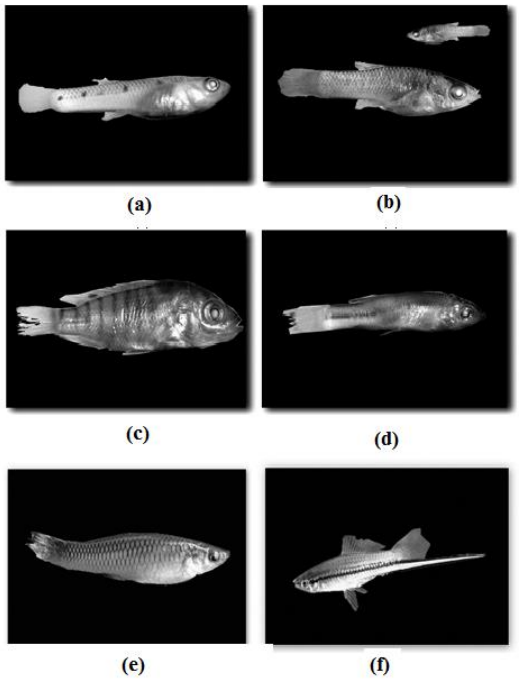

Fig. 2. Ichtyofauna photos collected at Apatlaco and Amacuzac, Morelos rivers.

Poecílidos **(a)** *Poecilopsis gracilis* (guatopote), **(b)** *Poecilia sphenops* (gupi) and **(e)** *Heterandria bimaculata* (guatopote manchado) are fishes distributed widely in all country regions and can tolerated urban and industry pollutants; the cichlid **(c)** *Oreochromis aureus* it's a tolerant organism to heavy metals pollutant; The specie **(d)** *Ilyodon* sp. belongs Goodeidae family only was found at Amacuzac river and can tolerate urban and agriculture wastes. **(f)** *Xiphophorus helleri* (sword tail fish) can tolerate urban pollutants.

Environmental indicators

Environmental indicators of the sampling sites were shown in Table 3. Only Tepeite site was not impacted by fecal coliform contamination and not has eutrophication tendency. Meanwhile

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Amacuzac and Tlatenchi sites showed suspension solids contamination. Tlatenchi site was the only register that not shown presence of sewage pollutant.

DISCUSSION

Tepeite site is the closest to the headwaters of Apatlaco therefore presents features so shallow oligotrophic and its water does not allow the establishment of fish stocks in the rainy season (July-October), which is corroborated criteria established by CNA (1997), indicating that fish absence is also linked to clean water.

Regarding Temixco station, it is very close to the city of Cuernavaca, which receives urban wastewater discharges with high fecal coliform impact and combined with the high temperature in the water, which was higher than in the other sites sampling, led to the presence of macroinvetebrados associated with water pollution and the lack of fish fauna and submerged vegetation (Vázquez 2003, Vazquez et al. 2006).

At Xochitepec, Amacuzac and Tlatenchi stations and pollution conditions were reported according to the environmental indicators, we also found the presence of submerged vegetation and fish. Fish populations showed different values of wealth and abundance. Importantly, the collected species are categorized as biological indicators of water quality as Huidobro (2000), observed small sizes and the presence of sexual dimorphism denoting the adult (Meyer *et al.* 1985 and Santillán 1996). It is noteworthy that the species *H. bimaculata, P. gracilis, P. sphenops* and *O. aureus* are tolerant of urban pollution and industrial type, which is why they are found in greater abundance, unlike X. helleri, which tolerates light pollution concentrations from urban (Huidobro 2000). In Amacuzac station recorded the presence of Ilyodon sp. that can be tolerated urban wastes, agricultural and livestock that are the result of the activities found in the area.

Table 1. Fish list and abundance per specie register in Apatlaco and Amacuzac, Morelos, rivers.

Order	Families	Species	July					October					
			A	B	C	D	E	A	B	C	D	E	Total
Cyprinodontiformes	Goodeidae	*Ilyodon* sp.	-	-	-	-	3	-	-	-	-	-	3
		Heterandria bimaculata	-	-	25	-	-	-	-	-	-	-	25
	Poeciliidae	*Poecilopsis gracilis*	-	-	28	-	204	-	-	-	181	111	524
		Poecilia sphenops	-	-	28	-	15	-	-	-	44	-	87
		Xiphophorus helleri	-	-	3	-	*	-	-	-	-	-	3
Perciformes	Cichlidae	*Oreochromis aureus*	-	-	-	-	4	-	-	-	-	-	4
													646

(A) Tepeite; (B) Temixco; (C) Xochitepec; (D) Tlatenchi; (E) Amacuzac

In summary, the presence of the fish fauna found in Temixco, Xochitepec, Tlatenchi and Amacuzac sites, allow classified these habitat as contaminated environments.

Note

Copies of the captured species were deposited in the National Collection of Fish Biology Institute of the National Autonomous University of Mexico (IBUNAM-P) with the following catalog numbers: 12725 Poecilopsis gracilis (Rio Apatlaco), 12728 Poecilopsis gracilis (Rio Amacuzac), Poecilia sphenops 12726 (Rio Apatlaco) Poecilia sphenops 12729 (Rio Amacuzac), Oreochromis aureus 12727 (Rio Amacuzac).

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Table 2. Habitat characteristics of sampling sites in Apatlaco and Amacuzac rivers, State of Morelos, México.

	Tepeite	Temixco	Xochitepec	Tlatenchi	Amacuzac
Geographical localization	18º 58' 32" Lat N 99º 16' 48" Long O	19º 51' 20" Lat N 99º 13' 23" Long O	18º 46' 56" Lat N 99º 14' 11" Long O	18º 26' 28" Lat N 99º 10' 81" Long O	17º 01' 07" Lat N 99º 00'01" Long O
River	Apatlaco	Apatlaco	Apatlaco	Apatlaco	Amacuzac
Access	Santa María neighborhood, Apatlaco birth river.	Cuernavaca-Alpuyeca. Temixco neighborhood. Km. 98 Burgos.	Federal road México-Acapulco, Temixco-Alpuyeca	Federal road Jojutla-Higuerón, Tlatenchi neighborhood.	México-Acapulco, highway. Alpuyeca-Chilpancingo, Las Huertas
Temperature	20ºC	29ºC	23.5 ºC	26 ºC	25ºC
Wheatear	Humid-Temperate	Warm-Humid	Warm-Humid	Warm-Humid	Warm-Humid
Vegetation	Tree, shrub, herbaceous.	Tree	Tree, shrub, herbaceous.	Tree, herbaceous.	Tree, shrub, herbaceous.
Dominant vegetation	Tree	Tree (Ahuehuetes)	Shrub	Herbaceous	Tree
Shores	Covered	Not covered	Partially covered	Partially covered	Covered
Slope	120 - 125º	120 - 125º	120 - 125º	120 - 125º	120 - 125º
Soil	Rocky, boulders.	Clay and lime	Boulder	Clay and lime	Rocky, boulders
Fauna	Amphibian, insects, birds	Insects	Aquatic birds, insects, fishes	Insects, fishes	Fishes, insects, birds
Harmful fauna	None	Dogs, cats and mice	Dog and cattle	Dogs, cats and mice	Cattle
River width	6 m	15 m	20 m	20 m	30m
Water depth	0.30 - 0.5 m	1.0 - 1.5 m	1.0 - 1.5 m	1.0 - 1.5 m	1.5 - 2.0
Water current	Rapids class 1	Rapids class 1	Rapids class 1	Rapids class 1	Rapids class 2
Water contamination	None	Color brown-green, trash, foam, oil, sewage smell, downloads, bubbles	Color brown-green, trash, foam, oil, sewage smell, downloads, bubbles	Color brown-green, trash, foam, oil, sewage smell, downloads, bubbles	Color brown, trash
Human activity	Aquaculture (trout). Few human settlements	Urbanized area	Middle urbanized area. Agriculture.	Urbanized area	Agriculture. Animal husbandry. Few human settlement

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Table 3. Weather indicators about sampling sites at Apatlaco and Amacuzac rivers, Morelos.

Station	Tepeite	Temixco	Xochitepec	Tlatenchi	Amacuzac
FECAL COLIFORM INDICATORS (NMP/100mL)					
Variable	**CF**	**CF**	**CF**	**CF**	**CF**
Criterion value	200-1000	200-1000	200-1000	200-1000	200-1000
Value summary	100	198000	56000	1406300	54500
Result	+	-	-	-	-
Qualification	**Not impact**	**High impact**	**High impact**	**High impact**	**High impact**
EUTROPHICATION INDICATOR (mg/L)					
Variable	**PO_4^{-3}**	**PO_4^{-3}**	**PO_4^{-3}**	**PO_4^{-3}**	**PO_4^{-3}**
Criterion value	0.10	0.10	0.10	0.10	0.10
Value summary	0.10	0.46	1.24	1.26	0.38
Result	+	-	-	-	-
Variable	**NO_3^-**	**NO_3^-**	**NO_3^-**	**NO_3^-**	**NO_3^-**
Criterion value	5.00	5.00	5.00	5.00	5.00
Value summary	0.23	1.92	1.42	0.70	0.92
Result	+	+	+	+	+
Result (both)	(+ +)	(- +)	(- +)	(- +)	(- +)
Qualification	**No tendency**	**With tendency**	**With tendency**	**With tendency**	**With tendency**
ENTRAINMENT OF SOLIDS INDICATOR (CE: mS/cm; SST: mg/L)					
Variable	**CE**	**CE**	**CE**	**CE**	**CE**
Criterion value	1000	1000	1000	1000	1000
Value summary	83.4	252.3	421.0	1033.6	782.2
Result	+	+	+	-	-
Variable	**SST**	**SST**	**SST**	**SST**	**SST**
Criterion value	500	500	500	500	500
Value summary	12	28	24	146	137
Result	+	+	+	+	+
Result (both)	(+ +)	(+ +)	(+ +)	(- +)	(- +)
Qualification	**Solid presence controlled**	**Solid presence controlled**	**Solid presence controlled**	**Solid presence**	**Solid presence**
SEWAGE PRESENCE INDICATORS (mg/L)					
Variable	**DBO_5**	**DBO_5**	**DBO_5**	**DBO_5**	**DBO_5**
Criterion value	10	10	10	10	10
Value summary	1.05	7.8	8.37	216	4.75
Result	+	+	+	-	+
Variable	**OD**	**OD**	**OD**	**OD**	**OD**
Criterion value	5.0	5.0	5.0	5.0	5.0
Value summary	7.37	6.67	5.53	2.04	5.05
Result	+	+	+	-	+
Variable	**$N\text{-}NH_4^+$**	**$N\text{-}NH_4^+$**	**$N\text{-}NH_4^+$**	**$N\text{-}NH_4^+$**	**$N\text{-}NH_4^+$**
Criterion value	1.0	1.0	1.0	1.0	1.0
Value summary	0.05	0.26	0.23	0.05	0.05
Result	+	+	+	+	+
Result (three)	(+ + +)	(+ + +)	(+ + +)	(- - +)	(+ + +)
Qualification	**Not presence**	**Not presence**	**Not presence**	**Cleary presence**	**Not presence**

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