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Macroinvertebrates as bioindicators of water quality in Actopan River, Veracruz, Mexico.

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ABSTRACT

Aquatic macroinvertebrates are considered as the best biological indicators of water quality. The study took place in Actopan River, located in Ursulo Galvan town, during May of 2014. Samples of macroinvertebrates were collected in two zones: Zone 1: Lomas San Rafael: shores with vegetation, plant detritus and mud; Zone 2, Ursulo Galvan Bridge: shores with vegetation, hard substratum, plant debris and submerged microphytes. In two sampled zones, 14 families were identified with 816 organisms, where Zone 2 had ten families (655 organisms) and Zone 1 presented only four families (161 organisms). The family Palaemoniidae (466) and Chironomidae (257) were the most abundant in sampling. Neritidae and Palaemoniidae families, were presented in both zones. BMWP index results show that health in zone 1 is in critical state (class IV, value 24, very contaminated waters) and zone 2 have an acceptable quality (class III, value 73, moderately contaminated waters). Urban, farming and industrial human activity, highly affects the water quality in Actopan River. Oceanographic characteristics of the Veracruz coastal zone and its interaction with rivers, estuaries and coral reef environments, demonstrate the high environmental heterogeneity of the Veracruz Reef System National Park (PNSAV). The PNSAV is a system dominated by anisotropic reef currents which enhance the biological connectivity between the northern, southern, coastal zone

Keywords: Macroinvertebrates, water quality, Actopan river.

RESUMEN

Los macro invertebrados acuáticos se consideran actualmente como los mejores indicadores biológicos de la calidad del agua. El estudio se llevó a cabo en el río Actopan, ubicado en el municipio de Úrsulo Galván, durante el mes de mayo de 2014. Se colectaron muestras de macro invertebrados en dos zonas: Zona 1: Loma San Rafael: orillas con vegetación, detritos vegetales y lodo; Zona 2, Puente Úrsulo Galván: orillas con vegetación, sustratos duros, detritos vegetales y macrófitas sumergidas. Se identificaron 13 familias en las dos zonas muestreadas con un total de 816 organismos, de las cuales la Zona 2 tuvo diez familias (655 organismos) en comparación de la Zona 1 que mostró solo cuatro familias (161 organismos). La familia Palaemoniidae (466) y la Chironomidae (257) fueron las más abundantes en el muestreo. Las familias Neritidae y Palaemoniidae, se presentaron en ambas zonas. Los resultados del índice de BMWP demuestran que la salud de la zona 1 se encuentra en estado crítico (clase IV, valor 24, aguas muy contaminadas) y la zona 2 presenta una calidad aceptable (clase III, valor 73, aguas medianamente contaminadas). La actividad humana, urbana, agrícola e industrial, afecta grandemente la calidad del agua del río Actopan.

Palabras clave: Macroinvertebrados, calidad de agua, río Actopan.

INTRODUCTION

Fluvial ecosystems are under several perturbations caused by human activities. Channels regulation and rectification, contamination by organic matter, eutrophication and mining, among others, produce changes in structure and function of river biological communities. One of the communities under these perturbations are benthonic

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macroinvertebrates, i.e. invertebrates that inhabit the riverbed and are visible to naked eye (Alonso 2004; Barba 2012). Aquatic macroinvertebrates are considered as the best water quality bioindicators, due to their size, wide distribution, high species richness, easy manipulation, ecological fidelity, short generational temporality and fragility against minimum observations. An organisms is considered a good water quality indicator, when it is found in an ecosystem with defined characteristics and when its population is higher than the rest of organisms found in same habitat (Roldan, 2003; Roldan and Ramírez, 2008).

Aquatic macroinvertebrates were used for first time in Mexico in 1985 and it was not until 2000 that there was an increase in the use of this biological group for environmental quality monitoring in epicontinental water bodies (Mathauriau et al. 2010). Rosas et al. (1985) were the firsts in using a biological index based in macroinvertebrates for water quality evaluation in Patzcuaro Lake, Mich. It was until the nineties, when Sánchez and García (1999) presented a study about bioindicators, using mainly these type of benthonic organisms. De la Lanza Espino et al. (2000) edited a book about these aquatic groups and biotic indexes used for water quality evaluation. Saldaña et al. (2001) applied the sequential comparison index (SCI) for water quality evaluation in Pescados River and in two tributaries of La Antigua River in Veracruz. Henne et al. (2002) used FBI index (Family Biological Index) to evaluate the impact of wastewater from a sugar mill in Ayuquila river basin (Colima, Jalisco). Hurtado et al. (2005) studied the structure and ecological changes in the macroinvertebrate community of San Juan river basin (Hidalgo and Querétaro state) using diversity indexes of similarity and equity, in order to lay foundation to develop plans for biological conservation. Huerto et al. (2005) used these organisms to evaluate the water quality in Amacuzac, Mor. and Balsas, Gro rivers; and where also used by Mathuriau et al. (2010) for quality evaluation of Queréndaro, Zinepécuaro, Chiquito, Grande de Morelia, San Marcos and La Palma rivers, all located in the hydrologic basin of Cuitzeo lake, Mich.

Actopan River, located in Ursulo Galvan River, Ver. has in its banks, an input of wastewater from different near urban spots, also there is a sugar mill that pours its residues of wastewater into the river. Therefore, the aim of this investigation consist in using a simple and cheap tool with the study of aquatic macroinvertebrate population to determine water quality of Actopan River.

MATERIAL AND METHODS

Study area

This study took place near the town of Chachalacas, Veracruz (Fig. 1) during the month of May of 2014. Chachalacas is located in central zone of Veracruz state, at coordinates 19° 24´ north and 96° 18´ west at an altitude of 20 meters above sea level.

Sample collection

A collection was made in two zones of Actopan River: Zone 1: Lomas San Rafael: shores with vegetation, plant detritus and mud; Zone 2, Ursulo Galvan Bridge: shores with vegetation, hard substratum, plant debris and submerged microphytes.

According to the zone, its characteristics, and with aim of hand nets and sieves with wooden frame, it was applied the corresponding sampling technique: 1) Hard substratum: gravels, cobbles and boulders were sampled by keeping the lower edge against the ground and dislodging the organisms, removing with the feet or hands in shallow areas; 2) Plant debris: (leaf litter, trunks of different size): were sampled by removing debris deposits with the feet or hands, maintaining the net downstream (with current) or by passing the net above them (in slow waters) to recollect organisms in suspension. Also accumulated wood in pits were sampled in this habitat, avoiding big pieces because generally those are difficult to sample in an adequate way; 3) Banks with

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vegetation: river banks with roots and emergent plants attached to them. Roots were shacked with hands or feet and the organisms in suspension or dragged by the current were recollected with the net located downstream; 4) Submerged macrophages: were sampled by dragging the net throw vegetation from the riverbed (where it takes root) up to the water surface. In shallow waters, the sampling was made by shaking the plants with feet or hands throughout 0.5 m, and recollecting the organisms in suspension or dragged down by current with the net; 5) Sand and other fine sediments: initially the net was dragged through the water surface for the obtainment of macroinvertebrates of water surface. It was avoided to drag the net through soft sediments to reduce residues in the samples.

Once the sample was obtained, it was deposited in a bucket for its transfer. Collected organisms were deposited in trays to separate macroinvertebrates from substrate; after the samples were cleaned invertebrates were separated by groups, these groups were: crustaceans, insect larvae and mollusks. Each of the groups were deposit in polyethylene cups with lids, which contained formalin at 10%, for later identification. In each zone, temperature, salinity, and dissolved oxygen (O.D.) were taken with a multiparametric YSI equipment model M86; water transparency was measured with a Secchi disc and a water sample was taken to obtain values of nitrites (NO2), ammonium (NH4) and phosphates (PO4) with a HANNA® multiparametric equipment for aquaculture.

Laboratory work

The identification of families of macroinvertebrates took place in laboratory, using the "Identification key of fresh water invertebrates" of the Ministry of Environment and Rural Areas of Spain Government and with help of a stereoscopic microscope Olympus SZ40. After the identification, it was applied the index of biotic quality BMWP (Biological Monitoring Working Party). Each family

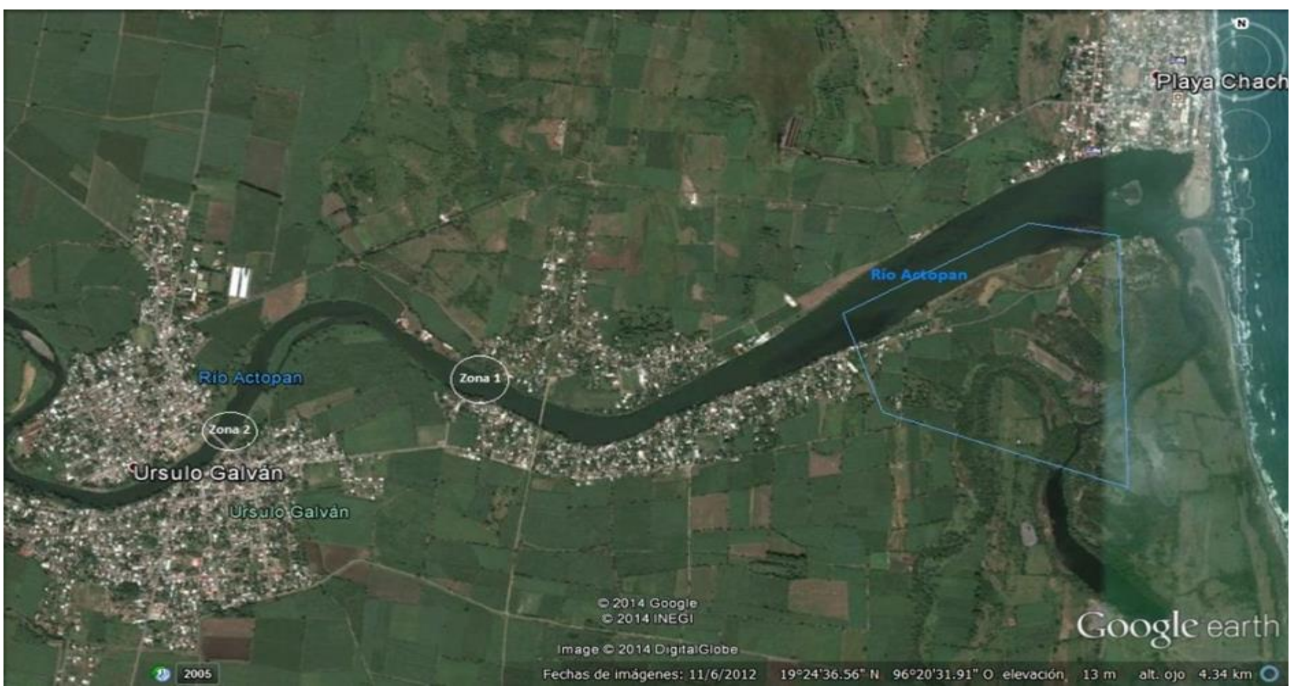

Fig. 1. Geographic location of Actopan river (took from Google Earth 2013).

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is given a number from 1 to 10, according to the contaminant sensibility grade 1 indicates less sensible, and so gradually to 10 (more sensitive), using classification proposed by Zamora (1999) and Roldán (1988) (Table 1).

Tale 1. Biotic quality index criteria BMWP.

Class	Rank	Quality	Characteristics	Colour
I	≥121	Very good	Very clean waters	Dark blue
II	101–120	Good	Clean waters	Light blue
III	61–100	Acceptable	Moderately polluted waters	Green
IV	36–60	Doubtful	Polluted waters	Yellow
V	16–35	Critical	Very contaminated waters	Orange
VI	≤15	Very critical	Strongly cotaminated waters	Red

Shannon – Weaver index (H'=-Σ pi* ln pi) was applied to measure biodiversity in the two zones and Jaccrad similarity coefficient (IJ=c/(a+b+c)), to compare the two sampling zones.

RESULTS

Abundancy in identified families

A total of 13 families were identified in the two sampling zones with a total abundance of 816 organisms, where Zone 2 had more abundancy with 10 families (655 organisms) and Zone 1 presented only four families (161 organisms). The families Neritidae and Palaemoniidae, were identified in both zones. Palaemoniidae (466) and Chironomidae (257) families were the most abundant in sampling (Table 2.).

Physicochemical parameters

Physicochemical parameters analysis show that D.O., salinity and nitrites levels are higher in Zone 2 than in Zone 1. Temperature is similar in both zones. Zone 1 show higher values in ammonium, phosphate, and turbidity. River current had more intensity in Zone 2 than in Zone 1 (Table 3).

Biotic Index BMWP

In Table 4 it is shown punctuation of BMWP index of each macroinvertebrate family. It can be shown that health in Zone 1 is between critical and very critical state and in Zone 2 it is between doubtful and critical state. Actopan River water quality is between contaminated and strongly contaminates waters conditions.

Reached Shannon index (H') was of 0.51573, which indicates that diversity is low. Jaccrad similarity index (J') was of 0.154, which shows that between the zones there are two unshared families.

DISCUSSION

This type of study with the abundancy and richness of families that are found in water bodies, especially aquatic macroinvertebrates and with support of physicochemical parameters, provides information about water quality conditions in Actopan River in a simple and cheap way. When making the biological evaluation as physicochemical it can be concluded that water quality in Actopan River in a general context goes from acceptable to critical, with moderately polluted waters to very contaminated.

It is observed that there are differences in abundancy and richness of macroinvertebrates between zones. Jacobson (1998), mentions that values of two biotic indexes (BMWP) tend to rise in upstream sites and decrease in downstream sites in dry season. In Zone 2 (upstream) more families were recollected as it can be seen in Table 4, besides

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Table 2. Macroinvertebrates abundancy in both study zones of Actopan River.

Phylum	Class	Order	Family	Abundancy		
				Zone 1	Zone 2	Total
Arthropoda	Insecta	Hemiptera	Nepidae	1	1	2
			Gerridae	6	6	12
		Diptera	Empididae (larva)	-	1	1
			Chironomidae (larva)	-	251	251
			Dixidae (larva)	-	6	6
		Heteroptera	Veliidae	-	1	1
		Ephemeroptera	Potamanthidae	-	27	27
		Coleoptera	Psephenidae	-	3	3
		Odonata	Libelulidae (larva)	-	9	9
	Crustacea. Malacostraca	Decapoda	Palaemoniidae	138	328	466
Mollusca	Gastropoda	Neritoidea	Neritidae	16	19	35
	Bivalvia	Veneroidea	Corbiculidae	-	10	10
			Total	161	655	816
			Families	4	10	12

Table 3. Physicochemical parameters values in both sampling zones of Actopan River, Ver.

Zone	D.O. mg L^{-1}	Temp. °C	pH	Salinity	NO_2	NH_3	PO_4	Turbidity
1	1.06	27.0	6.4	0.2	8.0	0.37	0.51	1.25
2	2.62	25.1	6.5	0.3	16.0	0.14	0.38	0.71

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Table 4. Punctuation of Biotic Quality index (BMWP) for each one of the collected families in Actopan River, Ver.

Phylum	Class	Order	Family	Biotic Quality Index	
				Zone 1	Zone 2
Arthropoda	Insecta	Hemiptera	Nepidae	6	-
			Gerridae	3	-
		Diptera	Empididae (larva)	-	5
			Chironomidae (larva)	-	2
			Dixidae (larva)	-	8
		Heteroptera	Veliidae	-	8
		Ephemeroptera	Potamanthidae	-	10
		Coleoptera	Psephenidae	-	10
		Odonata	Libelulidae (larva)	-	6
	Crustacea. Malacostraca	Decapoda	Palaemoniidae	8	8
Mollusca	Gastropoda	Neritoidea	Neritidae	7	7
	Bivalvia	Veneroidea	Corbiculidae	-	9
				24	73
			Quality	Critical	Acceptable

moderately polluted waters. Also, in Zone 2 it was collected more taxa, while in Zone 1, with a higher grade of contamination four families were collected. It must be emphasized that modification in the system made by human or environmental influences, the species that are in a specific spot and time, must adapt to those changes or disappear due to no tolerance. This leads to disappearance of certain groups and the rise of others, due to decreased intraspecific competition as predation and food, or by the combination of these factors (Roldán 1988, 2003, Vázquez et al. 2006).

Hurtado et al. (2001), mentions that handling of aquatic systems allows to determine physical and chemical environmental changes. Rivers have become domestic and industrial waste dumps, which causes an alteration in aquatic environment, like water and sediment contamination and chemical changes. These aquatic environment alterations provoke significate changes in plant and animal populations dynamic, also in the community structure over the time (Gutierrez 1999). In Actopan River banks there are two sugar mills that at finalization season of sugarcane harvest, they clean their installations and machinery and all is poured into the river (com. pers. of fisherman in the area); besides of counting with many towns that their dump goes directly into the river and people that wash their

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clothes with soap in riverside. These anthropic alterations can be causing the low values of dissolved oxygen found in the two study zones (< 3 mg L-1) and it can be compared to the results from the work of Henne et al. (2002), because they mention that sewage wastes from sugar mills poured into Ayuquila River, Jalisco, are responsible of low values of dissolved oxygen in the zone (< 5 mg L-1). On the other hand, the biotic index was highly correlated with phosphate concentration and minimum oxygen saturation, because Zone 1 presents higher values of phosphates and a low oxygen concentration, which can be observed in the quantity of families in the zone. There were no variations of pH between the zones which values are between 6.5 and 8.5 according to Water Quality Ecological Criteria (D.O.F. 13 of December of 1989), in Mexican Official Standard NOM-001-ECOL-1996.

We can conclude that physicochemical results, diversity and similitude index possess correlation and congruence in pointing out two types of obtained water quality in BMWP index analysis, where presence of sensible species to contamination of Ephemeroptera, Trichoptera and Plecoptera orders were minority regarding to families corresponding to Diptera (Chironomidae), Molusca (Neritidae, Corbiculidae) and Crustacea (Palaemonidae) orders which possess a higher resistance to contamination and low oxygen, giving to them a higher rate of production and population increase.

It is recommended to continue with this type of studies to determine change in populations of aquatic macroinvertebrates with respect to time, taking seasons of drought and rain.

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