IMPACT OF THE MUNICIPALITY OF MONTERIA IN DIVERSITY AND COMPOSITION OF RIVER MACROINVERTEBRATES SINÚ

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Abstract: The Sinú River is an important resource for the environment and economy of the department of Córdoba (Colombia), its waters cross the municipality of Montería, reason why the river is affected by the commercial, industrial and daily activities of the population. In general, the least affected areas are those located at the ends of the association of the river with the municipality, because they present a greater diversity and similarity, demonstrating in this way that human activities generate a significant impact on the natural dynamics of this ecosystem.

INTRODUCTION

At the global level, water pollution has become a serious problem, developing countries are considered to have the greatest impact because they discharge approximately 90% of the wastewater to the water bodies without treatment, contaminating Their sources of supply (Olguín et al., 2010; Langergraber & Muellegger, 2005). The main sources of water pollution are the direct discharge of domestic and industrial wastewater and the direct discharge of solid waste into bodies of water close to the towns and their disposal in open landfills without any control (Dourojeanni & Jouravlev, 1999).

The city of montería has one of the most important sources of waters of the Caribbean coast, the Rio Sinú divides the city in two, reason why it possesses an indisputable environmental importance, plays a vital role in the development of the economy and the Culture of those who inhabit its banks (Acosta, 2013), characteristics that drive the population growth with the river Sinú as axis. The growth of the population close to the body of water brings with it undeniable effects on the quality of Rio, considering that a significant part of the commerce of the city borders with the river Sinú, reason why the economic development manifests itself as a possible causer Of deterioration of the quality of the Sinú waters. Linked to city-specific effects, such as domestic and industrial activities on the riverbank, inherently a large amount and diversity of waste is generated, which when they reach the body of water can produce effects such as increased organic load , Decrease of dissolved oxygen, generation of bad odors, affectation to the associated biodiversity and deterioration of the natural beauty of this resource and its environment (López, 2009; CVS, 2009). The lack of an environmental culture by the citizens and the lack of adoption of environmentally relevant and adequate technologies in rural and urban areas for the treatment of waste are factors that allow for negative changes in the quality of the water resource , Which significantly affect the biodiversity and composition of the ecosystem formed by Rio (Olguín, Mercado & Sánchez-Galván, 2006; Olguín et al., 2010). As a side effect, the large contaminated rivers that reach the sea affect enormous areas, especially in bays and in marine basins such as the Caribbean (Dourojeanni & Jouravlev, 1999).

For the reasons stated above and because the Sinú River is the main source of water supply for the city of Montería, the diversity and composition of macroinvertebrates in the Sinu River was studied in search of the effect of human activities, management Inadequate of the residues and the vertimientos, since the macroinvertebrados are used as bioindicators of the quality of the waters, reason why its study is a method that provides complementary information to the physical-chemical evaluation, allowing to elucidate the degree of disturbance generated by the municipality On that basin.

Colombia is considered a country vulnerable to the effects of climate change, so it is important to study local biodiversity and its association with ecosystems to establish bases of action for conservation. Since in the city of Montería the Sinú River is constituted as a common element, but of great importance for the patrimonial legacy of the city, since the municipality uses resources like water, sediments and fish, in addition it is a reference of ecological tourism Of the city and around it lay important constructions for the continent, such as the second longest linear park in Latin America.

THEORETICAL FRAMEWORK

Surface freshwater sources: Surface freshwater sources are understood to be those that reside on the Earth's surface in rivers, streams, and lakes. Their importance is that they are the main sources of consumption and are habitats for animal and plant life, as well as having an important utility for recreation and transportation (Baird, 2001).

Water Pollution: One of the biggest problems facing surface water is that it is exposed to pollution of all kinds; Pollutants reach lakes and rivers from diverse and intermittent sources such as industrial and municipal waste, urban and agricultural drainage, soil erosion (Henrry & Heinke, 1999).

Water quality: Is not an absolute term; This depends on the use or activity to which the resource is destined, therefore, the objectives related to water quality are related to the intended uses (Armero, 2003). This suggests that a source of water that allows the life of the fish may not be suitable for swimming and water useful for human consumption may be unsuitable for the industry; Thus, in order to establish whether a water is fit for a particular purpose, its quality must be specified according to the use to be given. According to the above, water is said to be contaminated when it undergoes changes that affect its actual or potential use (CEPIS, 2004).

Aquatic macroinvertebrates and their use as bioindicators of water quality: The use of macroinvertebrates as bioindicators of water quality is based on the fact that these organisms occupy a habitat whose environmental requirements are adapted. Any change in environmental conditions will therefore be reflected in the structures of the communities that live there. A river that has suffered the effects of pollution is the best example to illustrate the changes that happen in the structures of the assemblies, which change from complex and diverse with organisms of clean water, to simple and low diversity with own organisms Contaminated water. The amount of dissolved oxygen, the degree of acidity or basicity (pH), the temperature and the quantity of dissolved ions (conductivity) are often the variables to which the organisms are sensitive, these variables easily change due to industrial and domestic contamination.

Much of what is known about the ecology of organisms depends on the degree of confidence they offer in the assessment of an aquatic ecosystem. One can simply speak of large groups, such as saying that, in general, ephemeroptera, plecoptera, tricópteros, are indicators of clean waters and that annelids and certain dipterans (chironomids) are indicators of contaminated water, but if you want To be more precise, one must speak of family, gender, and even better of species; Since not all ephemeroptera are equally indicators of clear water, nor all annelids of contaminated water.

Roldan & Ramírez (2008) extensively cover this theme and establish the basis for the study of aquatic fauna in general as indicators of water quality. The principle is relatively simple: under adverse conditions the organisms adapt or perish, therefore, the type of assembly that is in an ecosystem must reflect the environmental conditions that are prevailing there. Roldan (1999), presents a guide for the study of the macroinvertebrates of Antioquia, but largely applicable to similar Neotropical means, there are foundations for the classification of aquatic ecosystems of tropical basins, based on organisms typical of the region.

METHODOLOGY

Area of study: The municipality of Montería, capital of the department of Cordoba, is located in the middle part of the Sinú River basin, between the geographical coordinates at 8 ° 45 '27 "North Latitude and 75 ° 53' 34" Of Longitude West, to an elevation of 18 msnm, has an extension of 3141 km2 and counts on a total population of 420.711 inhabitants (Governor of Cordova, 2012); Its average temperature is 28 ° C, relative humidity is 85% and annual rainfall is 1200 to 1500 mm (Betancur, González & Reza, 2006). The rainy season extends from April to October, with average rainfall varying between 100 mm and 205 mm according to the month (Padilla & Gónima, 2015). The Rio Sinú, born in the Knot of Paramillo and flows into Boca de Tinajones, continues to the Bay of Cispatá, in the Caribbean Sea. It extends for 415 km, and in all its extension it irrigates 16 municipalities, among which is the municipality of montería crossing it from north to south by extension of 103 km of which 8 km cross the urban helmet of the municipality (Hermelin et al., 2007). The area that is the object of this study, is located within the section of the river that includes the urban area of the city, between the coordinates 08 ° 41,945 'N 075 ° 56,880' W and 08 ° 49,669 'N 075 ° 51,323' W in a longitude Approximately 7 km, being this section of direct influence of the urban area of the municipality of Montería on the river Sinú, where there is greater pressure on this stream of water by the deposit of solid and liquid waste (López, 2009; The Valleys of Sinú and San Jorge-CVS, 2012).

Field Phase: Six field visits will be carried out. In the first one, the area of study that allows the quantification of the spills and the establishment of sampling points for residual water, surface water and aquatic macroinvertebrates bioindicators . Samples are taken every two months, following a sampling plan.

Table 1. Geographical coordinates of the sampling points.

Sampling points	**Sampling location**	**Geographic Coordinates**	
		N	**O**
Point 1	Corregimiento Jaraquiel	8° 41' 54.58''	75° 56' 51.47''
Point 2	Bocatoma de planta de tratamiento de agua potable "Proactiva"	8° 44' 16.37''	75° 54' 39.98''
Point 3	Entre el barrio Rancho Grande y Caracolí	8° 44' 56.49''	75° 54' 7.05''
Point 4	Calle 24	8° 45' 14.78''	75° 53´28.76''
Point 5	Sucre	8° 46' 15.05''	75° 52' 54.91''
Point 6	Lavaderos del Norte	8° 46' 32.02''	75° 52' 14.53''
Point 7	Mocarí	8° 48' 7.66''	75° 51' 34.43''
Point 8	Garzones	8° 49' 40.07''	75° 51' 23.54''

The collected physicochemical samples were refrigerated for the purpose of preserving analyte integrity, during the sampling pH, Conductivity, Dissolved Oxygen and Temperature measurements were taken at each point sample and samples from the right bank, left bank and center Each sample point was measured with pH, Conductivity, Temperature and Sedimentable Solids, from which 3 subsamples were taken, which were used for BOD5, suspended solids, dissolved solids, total phosphorus, phosphates, color and turbidity, another For NKT which was preserved with sulfuric acid until reaching pH = 2, finally a sample for Fecal Coliforms was used. Samples taken for each sampling point and the integrated one were stored in containers according to their analytical purpose, refrigerated and sent to the SENA laboratory for determination.

In total, eight (8) sampling points were taken, each with samples taken on the right, center and left bank. The subsamples of each point were integrated to evaluate pH, Dissolved Oxygen OD, Turbidity, Color, Biochemical Oxygen Demand (BOD5), Total Suspended Solids (SST), Total Phosphorus (P), Phosphates (PO43-), Nitrates (N-NO3-), Total Nitrogen (N), Dissolved Solids, Temperature and Fecal Coliforms.

Field measurements were measured directly at the sampling site, using the Membrane electrode method for the measurement of dissolved oxygen, pH meter, conductivity meter and the temperature electrode that comes in conjunction with the pH meter (Table 2).

Table 2. Field Parameters.

PARÁMETROS DE CAMPO	MÉTODO	REFERENCIA
pH	Potentiometric	SM:4500-H B
Dissolved oxygen	Membrane Electrode	SM:4500-O C
Conductivity	Potentiometric	SM:2510 B
Temperature	Potentiometric	SM:2550 B

Laboratory analyzes were performed by the Laboratory of Environmental Quality and Research, as shown in Table 3.

Table 3. Laboratory parameters.

PARAMETER	METHOD	REFERENCE
Nitrates	UV Selective Spectrometry	SM:4500-NO3 B
Color	Spectrophotometric	SM:2120 C
Turbidity	Nephelometric	SM:2130 B
Phosphates	Spectrophotometric	SM:4500-P E
Total phosphorus	Spectrophotometric	SM:4500-P E
Total Dissolved Solids, SDT	Gravimetric	SM:2540 C
Total Suspended Solids, SST	Gravimetric	SM:2540 D
Biochemical Oxygen Demand, BOD5	Incubation 5 days - Modification Azida	SM: 5210 B - 4500-O C
Fecal coliforms	UV Selective Spectrometry	SM: 9222 B

The sampling of the biological component is carried out in six of eight sampling points, having as reference two upstream points, two midwater points and two last downstream points, the collection of individuals from the neuston has been done by means of a sweep surface with the network D and Jama, the organisms associated with the macrophyte roots were sampled with sieves of different mesh opening and with mesh of light mesh of 250μm and finally a manual collection was made, making three replicates of the procedures At each sampling site, sieves were also used for collection of benthic organisms. The collected macroinvertebrates were preserved in plastic bottles with screw cap with 70% alcohol and transported to the laboratory for later identification.

Laboratory Phase: Water samples were analyzed for the determination of physicochemicals, the samples followed a rigorous chain of custody, with standardized analytical procedures that allowed reliable results to be generated, analyzing the parameters:% dissolved oxygen saturation, MPN of fecal coliforms / 100ml, pH, Biochemical Oxygen Demand (BOD5), Nitrates, Total Phosphates, Deviation of equilibrium temperature, Turbidity, Total solids.
In order to carry out these analyzes, the methods officially accepted by the Ministry of Health in Decree 1594 of June 26, 1984, in Chapter XIV, of the methods of analysis and sampling were followed, and according to the methodologies described in Standard Methods for the Examination of Waters and Wastewaters. Ed 22 (SM).
Samples of macroinvertebrates, previously preserved in ethyl alcohol, will also be identified by means of taxonomic keys, following a rigorous examination of individuals to generate reliable family identification results, using stereoscope, Petri dishes and entomological tweezers.

Data analysis: The data obtained from the biological component are organized in a table in Microsoft Excel 2007. The numerical structure of aquatic macroinvertebrate populations in each sector will be described on the basis of variations in abundance, wealth (Margalef, 1958), Uniformity (Pielou, 1966), dominance (Simpson, 1949), diversity (Shannon-Wienner, 1949), similarity between Bray-Curtis stations (1957) and visualized graphically by NMDS (Non Metric Distance Scaling) , Which are performed using the software PRIMER 5 version 5.2.9. In addition, a Kruskal-Wallis analysis was performed and the diversity in the sampling sites was compared through the statistical program STARTGRAPHICS Centurión XV and applying a curve of species accumulation to evaluate if the expected wealth was equal to or not found, Through the program EstimateS820Win, version 8.2.0.

For the physico-chemical variables, the data set is organized in a calculation book in Microsoft Excel 2007. Using the program PRIMER 5, version 5.2.9, establishes the similarity between Bray-Curtis stations (1957) and establishes Visualized by NMDS (Non Metric Distance Scaling) analysis. Through the STARTGRAPHICS Centurion XV program, an ANOVA is performed to determine the significant difference of physical-chemical variables between stations. The estimation of water quality in urban rivers is an activity that has taken on a worldwide importance in recent decades (Olguín, Mercado & Sánchez-Galván, 2006). Therefore, the BMWP Index adapted for Colombia will be calculated from the assessment of the identification of macroinvertebrates (Roldan, 1999).

RESULTS

There will be 6 field visits, of which 3 have been completed, at the time of writing this summary, the first visit consisted of a pre-field inspection that allowed the establishment of 8 sampling stations for physico-chemical analysis and 6 for collection of Macrinvertebrates. The following two field visits have consisted of the execution of two of five samples that have been programmed.

For the biological component samples have been taken from the littoral associated to the left and right margins of the river, the first 204 individuals collected have been identified in 70%. In a preliminary way it can be stated that the families found have been Gerridae and Naucoridae (Hemiptera), Lycosidae and Pisauridae (Araneae), Atydae (Decapoda) and Neritidae (Gastropoda), indicating mainly an acceptable state of quality see Table 4.

Table 4. Classification of individuals found by family.

Phylum	Class	Order	Family
Arthropoda	Insecta	Coleoptera	Dystiscidae
			Hydrophilidae
			Noteridae
		Diptera	Culicidae
		Ephemeroptera	Baetidae
		Hemiptera	Gerridae
			Naucoridae
			Veliidae
			Notonectidae
			Hebridae

In a partial way it can be established that the water quality of the river presents an acceptable quality, as can be distinguished in Table 5.
The most representative order in the collections was Hemiptera with 84% of the catches, followed by Decapoda with 8%, whereas Diptera represented only 1% of the catches (see Figure 1). The order Hemiptera also presents the greatest diversity of families (see Table 4), with 5 families and 12 genera. Notably, the Guerridae family (Hemiptera) stands out as a dominant family, present in numerous ways at all points of sampling (Figure 2).
The composition of the families' distribution does not indicate an order directly related to the physicochemical properties of the river Sinu or with possible impacts associated with human activities on the river basin, since there is no pattern of biodiversity decline towards the points Medium or low, in reference to the sampling points that were located upstream.

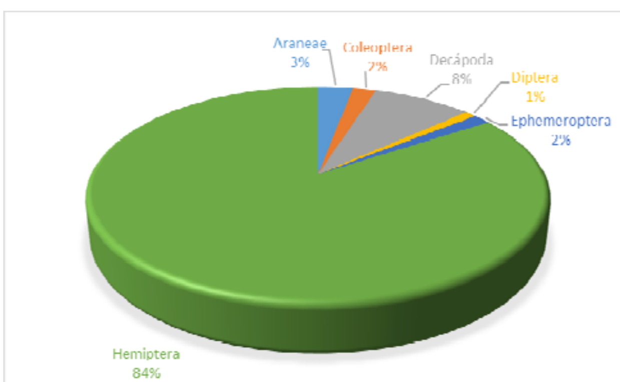

Figure 1. Collected orders.

At the same time, samples of water are collected for their physicochemical analysis. By a similarity analysis of Bray-Curtis for the results of the physicochemical analyzes it was found that the most similar points to each other are Jaraquiel and Mocarí with 99,952 of similarity. In general, the points located towards the extremes (upstream and downstream) are those that present a greater degree of similarity, which implies degrees of impact and physicochemical alteration in those that are closer to the center of the Municipality.

One of the main components of the project is participatory dissemination with the community as a strategy of social appropriation of knowledge. The idea is to promote the idea of Rio as an ecosystem rooted in tradition, in order to promote the generation of consciousness, which is expected to minimize Dumping and outbreaks of solid waste accumulation; The project is also expected to integrate local and environmental authorities as agents of change, it is expected that the results of the research support the baseline of generation of measures of protection of the basin and control of dumping.

Table 5. BMWP / Colombia Index for 6 sampling points.

Point of Sampling	Phyllum	Class	Order	Family	Score	BMWP Colombia	Quality	Meaning
Jaraquiel	Arthropoda	Insecta	Hemiptera	Gerridae	8	23	Critical	Aguas muy contaminadas
				Naucoridae	7			
				Veliidae	8			
Bocatoma Proactiva	Arthropoda	Insecta	Coleoptera	Dystiscidae	9	32		
			Hemiptera	Gerridae	8			
				Notonectidae	7			
				Veliidae	8			
Caracolí	Arthropoda	Insecta	Hemiptera	Gerridae	8	16		
				Veliidae	8			
Transito	Arthropoda	Insecta	Hemiptera	Gerridae	8	16		
				Veliidae	8			
Mocari	Arthropoda	Insecta	Coleoptera	Hydrophilidae	3	47	Doubtful	Aguas moderadamente contaminadas.
				Noteridae	4			
			Diptera	Culicidae	2			
			Ephemeroptera	Baetidae	7			
			Hemiptera	Gerridae	8			
				Hebridae	8			
				Naucoridae	7			
				Veliidae	8			
Garzones	Arthropoda	Insecta	Coleoptera	Noteridae	4	26	Critica	Aguas muy contaminadas
			Ephemeroptera	Baetidae	7			
			Hemiptera	Gerridae	8			
				Notonectidae	7			

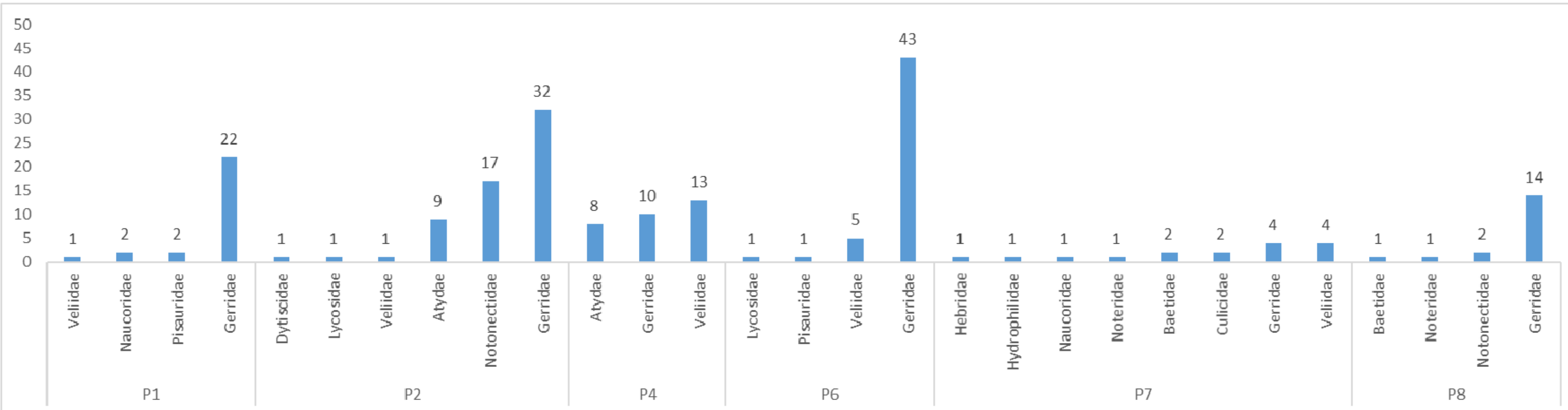

Figure 2. Composition of macroinvertebrates.

PARTIAL CONCLUSIONS

In general, it can be concluded that the diversity of macroinvertebrates may not be directly affected by the activities that take place around the Sinú river. Due to differences between water quality results from physicochemical and biological indices, it can be stated in a partial way that the punctual nature of the physicochemical samplings does not provide enough information to discriminate if there is no impact of the municipality on the ecosystem equilibrium. That the invertebrate macrofauna suggests that there is a slight degree of disturbance.

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