Benthic Macroinvertebrates as Monitors of Rio Grande Water Quality

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I. BACKGROUND/CONTEXT

The Rio Grande was named the most endangered river in North America in 1993 by *American Rivers*, the principal river conservation organization in the United States. American Rivers' concerns about the Rio Grande include headwater-to mouth degradation, pollution by mining operations along the river's northern section, and industrial and municipal wastes on both sides of the border along the lower Rio Grande (Coyle et.al. 1993). The Rio Grande was again listed by *American Rivers* as one of the nation's most endangered rivers in 2000.

The International Boundary and Water Commission (IBWC), Texas Natural Resource Conservation Commission (TNRCC), U.S. Environmental Protection Agency (USEPA), Texas Parks and Wildlife Department (TPWD), Texas Department of Health (TDH) and their Mexican counterparts undertook the most recent comprehensive assessments of water quality of the Rio Grande. These binational studies, carried out by federal and state agencies from the United States and Mexico studied the toxic substances in the water, sediments and fish tissues from El Paso/Juarez to Brownsville/Matamoros. Results were reported in the "Binational Study Regarding the Presence of Toxic Substances in the Rio Grande/Rio Bravo and its Tributaries Along the Boundary Portion Between the United States and Mexico" (1994) from one-time samples of 19 mainstream and 26 tributary sites. The Second Phase of the Study (1997) concentrated on areas of concern identified in the first phase of the study. Macroinvertebrate population analysis from the 1994 study showed that a site downstream of Laredo and Nuevo Laredo (Station 12, Rio Grande at pipeline crossing, 13.2 km downstream from International Bridge I at river km 567.6) was the most impacted of all sites sampled during the study. Of 18 major mainstream stations the only one to indicate a high potential for toxic chemical impact was the station downstream of Laredo/Nuevo Laredo. Based on the results of the 1994 study, the only sites to be examined for macrobenthic invertebrates during the follow-up study of 1997 were those downstream of Laredo/ Nuevo Laredo. The samples were actually collected before the Nuevo Laredo wastewater treatment Plant went on line in April of 1996. At that time an estimated 25-30 million gallons per day (MGD) of untreated wastewater was being discharged into the river (USEPA and IBWC 1997). Data from this sampling also indicated that water quality at station 12, downstream of Laredo/ Nuevo Laredo, was below that designated in the Texas Surface Water Quality Standards (TSWQS) for the segment of the river (Segment 2304). Other recent studies on the stretch of the river in the Laredo/ Nuevo Laredo area are those of Earhart, Vaughan and Montemayor (1995), and Vaughan (1999).

II. STATEMENT OF PROBLEM/RESEARCH QUESTION

This study attempts to answer two questions. The first question relates to the effect of the Nuevo Laredo Wastewater treatment Plant (NLWWTP) on water quality downstream of Laredo and Nuevo Laredo. The second goal of the study was to establish baseline data on the macroinvertebrate communities in the vicinity of the Colombia Solidarity Bridge (Bridge III) and the newly constructed World trade Bridge (Bridge IV). The rational for establishing these two monitoring sites is to be able to track changes in water quality, either improvement or degradation, in this section of the Rio Grande as growth and development continue on both sides of the border.

III. IMPORTANCE OF RESEARCH TOPIC

IBWC sampling of macroinvertebrates in this stretch of the Rio Grande has been done only twice during the past 9 years. Our data represents regular, periodic sampling over an ex ended and continuing time period. Also, as a result of our extended sampling, we have been able to detect changes in macroinvertebrate populations at the down river site indicating a gradual improvement in water quality since the NLWWTP came on line in April of 1996. Although there have been improvements in water quality as indicated by the macroinvertebrates population, the upriver site is still in better condition. Nuevo Laredo, even with the new $59.9 million NLWWTP, plus unserviced raw sewage outfalls, continues to release an estimated 8-10 million gallons per day (MGD) of untreated wastewater into the river. Until this problem is remedied it is unlikely that the quality of water indicated by the biota down river will match that of the upriver sites. Of further concern, and the reason for establishing the two new sampling sites is, the expected growth and development on both sides of the river in the vicinity of the Colombia and World Trade Bridges. If proper infrastructure for capturing and treating wastewater is not built the likelihood of deteriorating water quality in the upstream area will be a threat to the well being of citizens in both Laredo and Nuevo Laredo.

IV. DESCRIPTION OF RESEARCH METHODOLOGY

A number of methods are used to assess water quality. Most commonly, water chemistry is used to indicate the condition of a body of water. However, water chemistry only tells what the water quality is at a specific point in time. The kinds and numbers of organisms in a stream, however, reflect recent past and present conditions. Macroinvertebrates, animals without backbones and large enough to be seen with the naked eye, have long been used as biomonitors because they are a diverse group of long-.lived sedentary species that react strongly, and often predictably to human influences on aquatic ecosystems (Rosenberg and Resh 1993; Kolbe and Luedke, 1993). Benthic macroinvertebrates inhabit the bottom substrates of a stream or river, generally on debris, logs, macrophytes or on the undersides of rocks, for at least part of their life cycle (Rosenberg and Resh, 1993). Although the majority of benthic macroinvertebrates are insects, they also include such things as crustaceans (shrimp, crabs, crayfish), mollusks (snails and clams) and aquatic worms.

Monthly collections of macroinvertebrates were made, beginning in the winter of 1997, at one upriver location designated Site A, (27˚ 37'43" N and 99˚ 35' 22" W). This location was selected because it is upriver from most of the human activities of either Laredo or Nuevo Laredo and therefore relatively free of contaminants being generated and released by the sister cities. A downriver site at the Webb/ Zapata County Line (27˚ 15'83" N and 99˚ 27' 12" W) was designated Site D. This site is downstream of Laredo and Nuevo Laredo and therefore water quality is influenced by both cities. Sampling was done using the 5-minute kick-net protocol as outlined in Rosenberg and Resh, 1993 and Rosenberg, et.al. 1997. The kick-net is a D shaped metal frame holding a mesh bag of 4001µm. One end of the metal frame is attached to a wooden handle. The part of the bag that attaches to the frame is made of canvas to withstand abrasion. The investigator walks back and forth over the sampling area kicking up the substrate and then sweeping above the disturbed area to capture dislodged or escaping invertebrates. A standard time of 5 minutes was used in all collections. Since the level and flow in this reach of the Rio Grande is governed mainly by releases from Amistad Reservoir and fluctuates greatly, it was necessary to determine how far from the waters edge to sample each month. This was necessary to insure that the area being sampled had been underwater and therefore suitable macroinvertebrate habitat in the preceding weeks. A minimum of 100 individuals were collected on each occasion at each site. Once the 5-minute kick net sample was obtained the net and its contents were taken to the shore and organisms were picked off the net and from the rocks and debris that was trapped in the net. The specimens were preserved in vials of 70% ethyl alcohol.

In addition to the monthly samples from these two sites, two new sites were located and initial samples were taken to establish baseline data from these areas. One new site is approximately one half mile upstream of the Colombia Bridge (CB) (27° 42' 34" N and 99° 45' 08" W) and the other is downstream of the World Trade Bridge (WTB) near the mouth of Manadas Creek (2'7 ° 34' 08" N and 99° 30' 46" W). The number of suitable sites in this reach of the river are very limited, especially when flows are high. Both sites are near mid river and were reached using a kayak. Samples were taken using the kick net and were then transported to the riverbank for transfer to preservative.

V. DISCUSSION AND RESULTS

A number of indexes have been developed for comparing benthic macroinvertebrate species diversity and population size from different sites and different times. These indexes can then be used to make determinations on water quality changes. For this study, the samples for each site were combined into seasonal aggregates for analysis. For example the January -March samples were combined and considered to represent the winter sample; April-June samples were combined for the spring sample etc. This combining of monthly samples into seasonal samples gave us a total of 13 samples, winter 1997-Summer 2000. We analyzed the samples using a number of metrics to compare the macroinvertebrate populations from the two sites. For this report we used a metric known as the Major Group Biotic Index, which is used to compare samples from the same aquatic system. The Major Group Biotic Index is based on an estimate of the pollution tolerance of the major groups that makeup the macroinvertebrate community. Each major group is assigned a pollution tolerance value from 0-10, with 0 being intolerant and 10 being the most tolerant. The values are based on the pollution tolerance values for the most commonly found families in each major group (Dates and Byrne, 1997). As organic pollution increases, organisms with low tolerance tend to disappear from the community while organisms with high tolerance tend to increase, therefore increasing the biotic index A Biotic Index of 3.75 his been established as a threshold below which impact from pollution is minimal (Dates and Byrne, 1997). An increasing Biotic Index above threshold suggests an increasing impact from pollution (See Tables 1-5).

The yearly means of the Biotic Index values at Site A remained fairly constant (2.93, 2.75, 3.14, 2.86) from 1997 to 2000 indicating little impact from pollution. Yearly means of the Biotic Index values at Site D, however, showed moderate, but decreasing impact (4.28, 3.78, 3.86, 3.61) over the same period (See Table 6).

Seasonal Biotic Index values for Sites A and D throughout the period between 1997 and 2000 are graphed in Figure 1. With the exception of the aberrant Site D Biotic Index value in they spring of 1999 and the wider fluctuations at Site D throughout the sampling period, the seasonal pattern was very similar at both sites. The Biotic Index at Site D exceeded threshold three times in 1997, two times in 1998, and three times in 1999, but the average magnitude of threshold exceedance decreased over the period of study.

Two new upriver collecting localities were established in the summer of 2000. Two replicate samples were collected from each site and are referred to as CB1 and CB2, and WTB1 AND WTB2 in Table 5. The Major Group Biotic Index for the Colombia Bridge site was 2.41 for both replicates while the World Trade Bridge site scored 2.7 and 2.8. These numbers are similar to the summer 2000 for Site A which scored 2.61 and much lower than the summer 2000 for Site D which was 3.79. These numbers indicate that the water quality from above the Colombia Bridge to below the World Trade Bridge is less impacted than the water below Laredo and Nuevo Laredo.

Table 1. Major Biotic Group Index for Site A and D 1997

Major Group Biotic Index

Spring 1997		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	23=	46	22=	44
Plecoptera	1X	=	=		
Tricoptera	3X	43=	129	2=	6
Chironomidae	7X	3=	21	12=	84
Other Diptera	4X	=		=	
Odonata	5X	1=	5	=	
Megaloptera	2X	=		1=	2
Coleoptera	4X	=		4=	16
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		=	
Pelecypoda	7X	=		=	
Oligochaeta	9X	2=	18	=	
Hirudinea	10X	1=	10	1=	10
Total		73	229	42	162
Biotic Index		229/73	**=3.14**	162/42	**=3.90**

Major Group Biotic Index

Summer 1997		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	144=	288	38=	76
Plecoptera	1X	=		=	
Tricoptera	3X	17=	51	14=	42
Chironomidae	7X	4=	28	56=	392
Other Diptera	4X	=		=	
Odonata	5X	4=	20	4=	20
Megaloptera	2X	1=	2	2=	4
Coleoptera	4X	2=	8	79=	316
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		=	
Pelecypoda	7X	=		=	
Oligochaeta	9X	=		2=	18
Hirudinea	10X	=		7=	70
Total		190	523	227	1113
Biotic Index		523/190	**=2.75**	1113/227	**=4.90**

Major Group Biotic Index

Fall 1997		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	18=	36	6=	12
Plecoptera	1X	=		=	
Tricoptera	3X	4=	12	8=	24
Chironomidae	7X	=		=	
Other Diptera	4X	=		=	
Odonata	5X	1=	5	=	25
Megaloptera	2X	=		=	
Coleoptera	4X	1=	4	11=	44
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		5=	35
Pelecypoda	7X	4=	28	1=	7
Oligochaeta	9X	=		=	
Hirudinea	10X	=		=	
Total		28	85	31	147
Biotic Index		85/28	**=3.04**	147/31	**=4.74**

Major Group Biotic Index

Winter 1997		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	72=	144	68=	136
Plecoptera	1X	=		=	
Tricoptera	3X	18=	54	39=	117
Chironomidae	7X	2=	14	22=	154
Other Diptera	4X	6=	24	21=	84
Odonata	5X	1=	5	4=	20
Megaloptera	2X	=		=	
Coleoptera	4X	3=	12	14=	56
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		8=	56
Pelecypoda	7X	7=	49	1=	7
Oligochaeta	9X	=		=	
Hirudinea	10X	=		=	
Total		109	302	177	630
Biotic Index		302/109	**=2.77**	630/177	**=3.56**

(T) Tolerance Value
(D) Density

Table 2. Major Biotic Group Index for Site A and D 1998

Major Group Biotic Index

Spring 1998		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	225=	450	132=	264
Plecoptera	1X	=		=	
Tricoptera	3X	16=	48	58=	174
Chironomidae	7X	=		24=	168
Other Diptera	4X	2=	8	=	
Odonata	5X	6=	30	=	
Megaloptera	2X	1=	2	5=	10
Coleoptera	4X	9=	36	50=	200
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	1=	7	7=	49
Pelecypoda	7X	18=	126	6=	42
Oligochaeta	9X	=		=	
Hirudinea	10X	=		=	
Total		278	707	282	907
Biotic Index		707/278	**=2.54**	907/282	**=3.22**

Major Group Biotic Index

Summer 1998		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	190=	380	110=	220
Plecoptera	1X	=		=	
Tricoptera	3X	10=	30	49=	147
Chironomidae	7X	6=	42	10=	70
Other Diptera	4X	24=	56	24=	56
Odonata	5X	4=	20	1=	5
Megaloptera	2X	=		=	
Coleoptera	4X	11=	44	68=	272
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	5=	35	3=	21
Pelecypoda	7X	7=	49	4=	28
Oligochaeta	9X	2=	18	=	
Hirudinea	10X	=		1=	10
Total		260	680	270	829
Biotic Index		680/260	=**2.78**	1244/310	**=4.01**

Major Group Biotic Index

Fall 1998		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	170=	340	93=	186
Plecoptera	1X	=		=	
Tricoptera	3X	35=	105	8=	24
Chironomidae	7X	15=	105	88=	616
Other Diptera	4X	2=	8	=	
Odonata	5X	8=	40	1=	5
Megaloptera	2X	=		=	
Coleoptera	4X	1=	4	19=	76
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	13=	91	=	
Pelecypoda	7X	14=	98	8=	56
Oligochaeta	9X	=		3=	27
Hirudinea	10X	=		13=	130
Total		258	791	233	1120
Biotic Index		91/258	**=3.07**	1120/233	**=4.81**

Major Group Biotic Index

Winter 1998		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	246=	492	143=	268
Plecoptera	1X	=		=	
Tricoptera	3X	55=	165	28=	84
Chironomidae	7X	6=	42	39=	273
Other Diptera	4X	33=	132	43=	172
Odonata	5X	14=	70	=	
Megaloptera	2X	=		=	
Coleoptera	4X	30=	120	19=	76
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	3=	21	7=	49
Pelecypoda	7X	4=	28	2=	14
Oligochaeta	9X	3=	27	=	
Hirudinea	10X	=		29=	290
Total		394	1097	310	1244
Biotic Index		1097/394	**=2.78**	1244/310	**=4.01**

(T) Tolerance Value
(D) Density

Table 3. Major Biotic Group Index for Site A and D 1999

Major Group Biotic Index

Spring 1998		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	166=	332	193=	386
Plecoptera	1X	=		=	
Tricoptera	3X	20=	60	34=	102
Chironomidae	7X	20=	140	29=	203
Other Diptera	4X	=		=	
Odonata	5X	4=	20	1=	5
Megaloptera	2X	=		=	
Coleoptera	4X	6=	24	16=	64
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		1=	7
Pelecypoda	7X	10=	70	3=	21
Oligochaeta	9X	2=	18	=	
Hirudinea	10X	=		=	
Total		228	664	277	788
Biotic Index		664/228	**=2.91**	788/277	**=2.84**

Major Group Biotic Index

Summer 1998		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	193=	386	97=	194
Plecoptera	1X	=		=	
Tricoptera	3X	56=	168	14=	142
Chironomidae	7X	3=	21	57=	399
Other Diptera	4X	68=	272	=	
Odonata	5X	7=	35	2=	10
Megaloptera	2X	3=	6	1=	2
Coleoptera	4X	2=	8	9=	36
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		2=	14
Pelecypoda	7X	13=	91	2=	14
Oligochaeta	9X	2=	18	=	
Hirudinea	10X	=		=	
Total		347	1005	184	711
Biotic Index		1055/347	**2.90**	711/184	**=3.86**

Major Group Biotic Index

Fall 1999		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	140=	280	171=	342
Plecoptera	1X	=		=	
Tricoptera	3X	20=	60	17=	51
Chironomidae	7X	12=	84	25=	175
Other Diptera	4X	5=	20	1=	4
Odonata	5X	4=	20	2=	10
Megaloptera	2X	1=	2	1=	1
Coleoptera	4X	5=	20	30=	120
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		1=	7
Pelecypoda	7X	3=	21	2=	14
Oligochaeta	9X	12=	108	1=	9
Hirudinea	10X	=		37=	370
Total		202	615	288	1104
Biotic Index		615/202	**=3.04**	1104/288	**=3.83**

Major Group Biotic Index

Winter 1999		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	98=	196	37=	74
Plecoptera	1X	=		=	
Tricoptera	3X	48=	144	7=	21
Chironomidae	7X	34=	238	35=	245
Other Diptera	4X	66=	264	4=	16
Odonata	5X	9=	45	=	
Megaloptera	2X	2=	4	1=	2
Coleoptera	4X	2=	8	1=	4
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		2=	14
Pelecypoda	7X	10=	70	8=	56
Oligochaeta	9X	3=	27	=	
Hirudinea	10X	=		7=	70
Total		272	966	102	502
Biotic Index		996/272	**=3.66**	502/102	**=4.92**

(T) Tolerance Value
(D) Density

Table 4. Major Biotic Group Index for Site A and D Spring and Summer 2000.

Major Group Biotic Index

Spring 2000		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	56=	112	102=	204
Plecoptera	1X	=		=	
Tricoptera	3X	13=	39	2=	6
Chironomidae	7X	2=	14	9=	98
Other Diptera	4X	19=	76	=	
Odonata	5X	6=	30	=	
Megaloptera	2X	3=	6	1=	2
Coleoptera	4X	1=	4	9=	36
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		7=	49
Pelecypoda	7X	6=	42	9=	63
Oligochaeta	9X	1=	9	=	
Hirudinea	10X	=		3=	30
Total		107	332	142	488
Biotic Index		332/107	**=3.10**	488/142	**=3.44**

Major Group Biotic Index

Summer 2000		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	191=	382	141=	282
Plecoptera	1X	=		=	
Tricoptera	3X	18=	54	7=	21
Chironomidae	7X	7=	49	61=	427
Other Diptera	4X	5=	20	3=	12
Odonata	5X	1=	5	3=	15
Megaloptera	2X	=		=	
Coleoptera	4X	3=	12	17=	68
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		8=	56
Pelecypoda	7X	15=	105	7=	49
Oligochaeta	9X	=		1=	9
Hirudinea	10X	=		=	
Total		240	627	248	939
Biotic Index		627/240	**=2.61**	939/248	**=3.79**

Table 5. Major Biotic Index for Columbia Bridge (CB1 and CB2) and World Trade Bridge (WTB1 and WTB2) Summer 2000.

Major Group Biotic Index

Fall 1999		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	87=	174	110=	220
Plecoptera	1X	=		=	
Tricoptera	3X	4=	12	4=	12
Chironomidae	7X	=		1=	7
Other Diptera	4X	=		=	
Odonata	5X	1=	5	4=	20
Megaloptera	2X	=		1=	2
Coleoptera	4X	5=	20	6=	24
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	=		=	
Pelecypoda	7X	2=	14	4=	28
Oligochaeta	9X	2=	18	=	
Hirudinea	10X	=		=	
Total		101	243	130	313
Biotic Index		243/101	**=2.41**	313/130	**=2.41**

Major Group Biotic Index

Winter 1999		**SITE A**		**SITE D**	
Major Group	**(T)**	**(D)**	**T x D**	**(D)**	**T x D**
Ephemeroptera	2X	108=	216	118=	236
Plecoptera	1X	=		=	
Tricoptera	3X	5=	15	7=	21
Chironomidae	7X	2=	14	4=	28
Other Diptera	4X	=		=	
Odonata	5X	=		=	
Megaloptera	2X	=		=	
Coleoptera	4X	2=	8	=	32
Amphipoda	7X	=		=	
Isopoda	8X	=		=	
Decapoda	6X	=		=	
Gastropoda	7X	1=	7	=	
Pelecypoda	7X	13=	91	11=	77
Oligochaeta	9X	=		=	
Hirudinea	10X	=		=	
Total		131	351	140	394
Biotic Index		351/131	**=2.70**	394/140	**=2.80**

(T) Tolerance Value
(D) Density

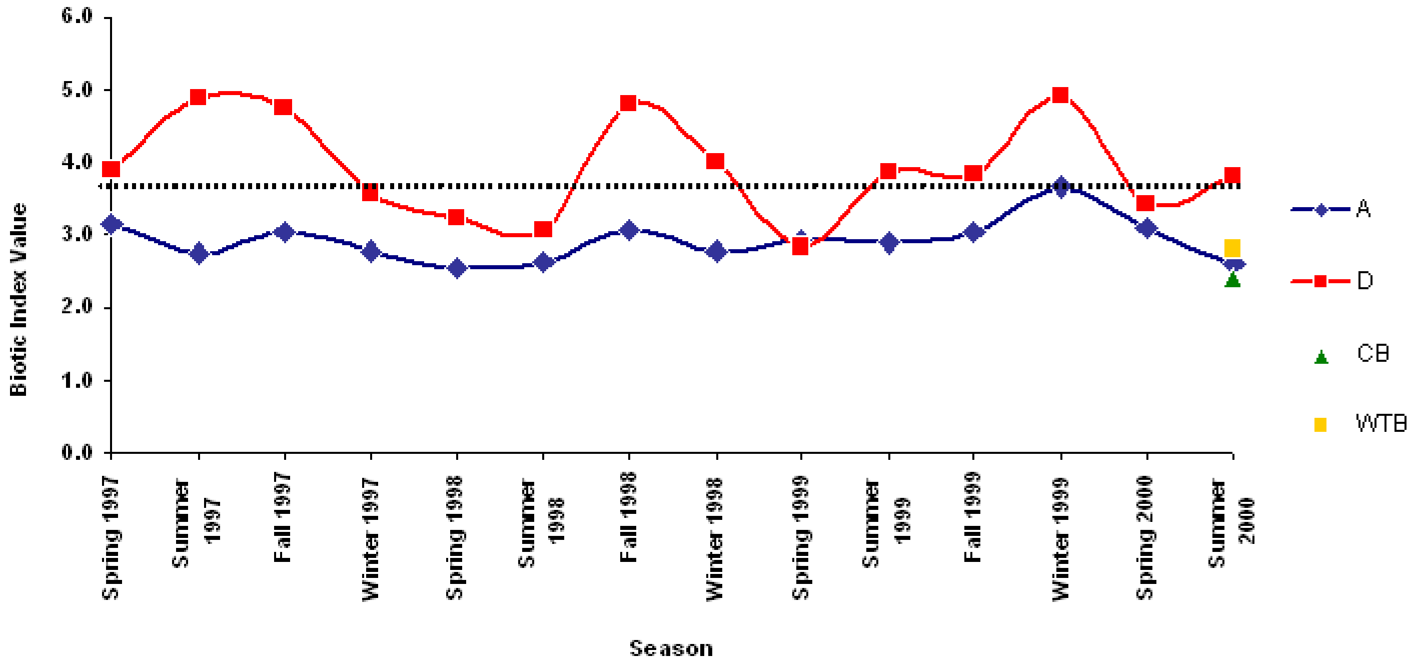

Figure 1. Biotic Index Values by Season for Sites A and D. Spring 1997 - Summer 2000

Values ranging from 0 to 3.75 shows no impairment

Table 6. Mean annual Biotic Index for Site A and D

Site A	Site D
2.93	4.28
2.75	3.78
3.14	3.86
2.86	3.61

VI. CONCLUSIONS AND RECOMMENDATIONS

Changes in the composition of the benthic macroinvertebrate population downstream of Laredo/Nuevo Laredo, as shown by this study, indicate that there has been an improvement in water quality in that reach of the river. This improvement is attributed to the operation of the NLWWTP that came on line in 1996. Although conditions have improved, water quality downstream is still being impacted by the sister cities.

It is imperative that Nuevo Laredo builds the infrastructure to treat the estimated 8 - 10 million gallons of raw sewage that it still contributes to the Rio Grande each day. As growth and development take place on both sides of the river, especially up river in the vicinity of the World Trade and Colombia Bridges, increasing quantities of sewage will be produced . It is therefore, necessary that the infrastructure be put in place to capture and treat the increasing quantity of sewage that will be produced.

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