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ASSESSMENT OF THE SINOS RIVER BASIN WATER QUALITY THROUGH BMWP, STATE OF RIO GRANDE DO SUL, BRAZIL

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Abstract: The aquatic macroinvertebrate fauna is an important component of continental limnic ecosystems, acting in several processes of important biocomplexity. Benthic macroinvertebrates are an important tool in the evaluation of the quality of aquatic ecosystems, due to their particularities and occurrences in the environment. The present study characterized the structure of the macroinvertebrate community and evaluated water quality through the application of the index "Biological Monitoring Working Party" (BMWP), in Sinos River Hydrographic Basin (SRHB), RS. Sampling was carried out from January to December 2023 at three points in the basin, abiotic variables were recorded and, in the laboratory, the sampled animals were screened, identified to family and quantified. The BMWP was calculated for each point and values for invertebrate families were also adjusted for the basin in question. A total of 2,568 specimens were sampled over the period and used for the final calculation of the index, generating the $BMWP_{\text{Sinos Index}}$. The Paranhana River is the most impacted in the SRHB, and contributes to the deterioration of the waters of the Sinos River, from the Municipality of Taquara, the final value totaled a score of 102, with the water being considered polluted. The point located in the Sinos River itself and the one located in the Rolante River presented similar results (253 and 262 respectively) with positive evaluations (non-polluted waters).
Keywords: biomonitoring, biological index, benthic macroinvertebrates, BMWP

INTRODUCTION

Aquatic ecosystems, particularly lotic ecosystems, have been suffering a significant decline in their biodiversity and significant loss of habitats due to human activities. The allocation of large areas of land for agriculture, the construction of dams, urban and industrial development, and pollution are factors that actively contribute to the degradation of these ecosystems (DUDGEON, 2019). Human-caused climate change poses a major threat to the biodiversity of freshwater systems; the increase in global temperature causes a direct change in rainfall and flood patterns, glacial melting, and may also contribute to an increase in the frequency of extreme events (REID et al., 2019).

There is growing development in evaluation techniques for monitoring the water quality of rivers and estuaries using pollution bioindicators. These techniques emphasize that they are simple, fast, and less expensive than analytical techniques, with repeatability and acceptable scientific validity (LÓPEZ-HERNÁNDEZ et al., 2024)

Originating in the United Kingdom in 1976, the Biological Monitoring Working Party (BMWP), it is a biotic index widely used in the biomonitoring of aquatic ecosystems. The index adopts a system that consists of collecting macroinvertebrates in all habitats of a given stretch and identifying them down to their families. The water classification basis takes into account a list of taxa that are more and less tolerant to pollution, where a value is assigned to each family and thus determines the environmental condition of the location (ALBA-TERCEDOR & SÁNCHEZ-ORTEGA, 1988). The index has been widely used and adapted in several countries, with the addition of new families and changes in the values attributed to the sensitivity of some taxa in order to best meet the reality of each location (DUDGEON, 2019). In Brazil, the

BMWP index was adapted for the Velhas River Hydrographic Basin, MG (JUNQUEIRA & CAMPOS, 1998), for the Meia Ponte River Hydrographic Basin, GO (MONTEIRO et al., 2008) with the inclusion of families with the highest frequency in the country.

The present study characterized the structure of the aquatic macroinvertebrate community and evaluated water quality through the application of the BMWP (Biological Monitoring Working Party) biological index, in the Sinos River Hydrographic Basin (SRHB), one of the most degraded hydrographic basins in Rio Grande do Sul.

MATERIAL AND METHODS

Brazil is divided into 12 Hydrographic Regions, including the South Atlantic Hydrographic Region, which, in turn, is divided into three units: Guaíba, Coastline/RS and Coastline/SC-PR (ANA, 2015).

In the eastern part of the Guaíba Hydrographic Region is located the Sinos River Hydrographic Basin (SRHB), with an area of 3,696 km², partially or totally covering the territories of 32 municipalities, with an estimated population of 1,447,678 inhabitants, with 1,375,288 inhabitants in urban areas and 72,390 inhabitants in rural areas. (ANSCHAU, 2016; COMITESINOS, 2023; SEMA, 2023). Its main watercourse is the Sinos River, which has its source in the municipality of Caraá and mouth in the municipality of Canoas, totaling 190 km in length. Rolante, da Ilha and Paranhana, are its main tributaries. (ANSCHAU, 2016).

In order to determine physical and chemical characteristics, benthic macroinvertebrate and water samples were collected in three different sites along the drainage basin (Figure 1), in the major water bodies: upper Sinos River, Rolante River and Paranhana River, always in superficial waters of the water body itself.

P1 – Site 1 - (29°45’45”S/50°19’37”W). City of Caraá. This sampling site is located in the beginning of the formation of the Sinos River, although it is not characterized as the source of the river, as it already presents the influence of some small contributors. At this location, there are strong currents and whenever compared to the other two sites the bottom is made up of a rocky substrate, pebbles with various sizes intermingled with little decomposing organic matter. The city presents an area of 29.461 hectares of which 23% are still originally covered by the Atlantic forest (SOS Mata Atlântica, 2024). Sampling point does not suffer the impact of great urban conglomerates located on upstream, thus the anthropic impact is considered low.

P2 – Site 2 - (29°38’34”S/50°32’33”W). City of Rolante. This sampling site is located in the Rolante River, five kilometers upstream of city center (urban density) and receives contributions from rivers Riozinho and Mascarada (MAGNA ENGENHARIA, 1996), the river drains an area of 500 km². Sampling point is located 22 km from the mouth of the Sinos River, which is located in the rural area of the city of Taquara. The river currents are strong at sampling site and the bottom is made up of a sandy and rocky (pebbles) substrate, with various sizes intermingled with decomposing organic matter made up mainly of tree leaves from riparian vegetation located upstream. A greater environmental heterogeneity is found at this point with the decomposition of the sandy substrate. The city presents an area of 29.609 hectares of which 16,5% are still originally covered by the Atlantic forest (SOS Mata Atlântica, 2024). Sampling point is under the impact of large urban conglomerates located upstream, such as the cities of Riozinho and São Francisco de Paula.

P3 – Site 3 - (29°36'10"S/50°48'49"W). City of Igrejinha. This sampling site is located in the Paranhana River, five kilometers downstream of city center (urban density) and 15 kilometers from the mouth of the Sinos river, which is located in the rural area of the city of Taquara, according to Magna Engenharia (1996) the river drains an area of 580 km². The river currents are strong at sampling site and the bottom is made up of a sandy and rocky (pebbles) substrate, with various sizes intermingled with decomposing organic matter made up mainly of tree leaves from riparian vegetation located upstream. A greater environmental heterogeneity is found at this point with the decomposition of the sandy substrate. The city presents an area of 13.830 hectares of which 22% are still originally covered by the Atlantic forest (SOS Mata Atlântica, 2024). At this point, the Salto Dam System is important for the water dynamics of the river, since the dam system enables the regularization and transposition of water from the Caí river basin to the Sinos river basin for the production of electricity since 1956 through the Paranhana River (BLUME et. al., 2010), thus, the water from the Caí river flows through this site in an inconstant and variable manner with maximum water flow of up to 11.6 m^3/s for this transposition. Sampling point is partially under the impact of large urban conglomerates located upstream, such as the cities of Três Coroas, Gramado, Canela and São Francisco de Paula.

Measurement of dissolved oxygen and fecal coliform (*Escherichia coli*), was conducted by the Analytic Department at FEEVALE University, a FEPAM-RS certified laboratory. Sample collection, as well as all measurements, was carried out according to the Standard Methods for Examination of Water and Wastewater, 22st Ed (APHA, 2012). Water temperature and pH were recorded in the field by using pHmetro Hanna Instruments (HI 98128).

Macroinvertebrate and water sampling to determine physical and chemical characteristics took place from January to December 2023. Sampling of benthic macroinvertebrates was carried out using the kick-sampling methodology, where an aquatic net (puçá) with dimensions of 60 x 40cm, an inter-node opening of 2 mm, was positioned against the water flow and the substrate (gravel, sand and leaf litter) was turned over with the feet. All collected organisms were fixed on site using 70% ethanol and were stored in plastic buckets. Once in the laboratory, the material was screened and the samples were indentified up to family type by using bibliography according to each taxonomic group (LOPRETTO & TELL, 1995; MERRIT & CUMMINS, 1996; SALLES et al., 2004; BENETTI et al., 2006; COSTA et al., 2006; MANSUR & PEREIRA, 2006; FROEHLICH, 2007; MUGNAI et al., 2010; CARTER et al., 2011; PAISLEY et al., 2014).

Classification of organisms as to pollution tolerance was performed based in the BMWP index adapted for Brazil by the state of Paraná Environmental Institute (IAP, 2003), adjusted for the SRWB, and then named $BMWP_{Sinos\ Index}$. According to LOYOLA (2000), this method identifies benthic organisms at the family taxonomic rank and establishes scores for each group or family based on their tolerance to impact. Scores range from one to ten and are attributed according to the sensitivity of taxonomic groups to organic pollutants. Families that are sensitive to high levels of pollutants were awarded higher scores, whereas tolerant families were awarded lower scores. Total scores are qualitatively measured, not quantitatively, which means that scores are added by recording family specimens that are found, and not by recorded quantity. Table 1 shows framing of the waterbody according to scored originated by the total amount of families of $BMWP_{Sinos\ Index}$.

Table 1. Classification and meanings for SRWB water quality (Castro *et. al.*, 2017) according to scores originated by the total amount of families of $BMWP_{Sinos\ Index}$ (adapted by the authors)

Classe	Qualidade	Valor/Total	Significado
I	VERY GOOD	**> 241**	Clean, unpolluted waters
II	GOOD	181-240	Slightly polluted waters
III	ACCEPTABLE	121-180	Polluted waters
IV	POLLUTED	61-120	Very polluted waters
V	VERY POLLUTED	**< 60**	Heavily polluted waters

RESULTS AND DISCUSSION

PHYSICAL AND CHEMICAL CHARACTERISTICS

HAWKES (1975) characterizes a ritral stretch as one with an annual temperature variation that does not exceed 20ºC. Temperature varied less at all three sampling sites: P1 (8.1 up to 22.7ºC; μ=16,7ºC), P2 (9.0 up to 24.6ºC; μ=18.1ºC) and P3 (9.0 up to 25.6ºC; μ=19,0ºC). The smallest amplitude is found at P1, followed in order by P2 and P3 (Figure 2). The same behavior was found regarding average annual temperature, with a temperature increase towards the basin mouth. This classification based on thermal balance could encompass stretches such as mountain rivers, but the sites are already in locations where there is a slowdown in laminar flow.

Neutral values were found for pH annual average (P1: 6,9, P2: 7,05 and P3: 6,8), which was calculated over the 12 months. These are expected values to be found at neutral continental waters, being within the expected variation predicted by CONAMA resolution 357/2005 for class 1 waters. Extreme recorded pH values were 6.17 (the smallest) at P3 and 7.69 (the highest) at P1 (Figure 3). Most aquatic organisms is highly sensitive to pH variations, and waters that are too acid or too alkaline may be harmful to aquatic communities, therefore recorded pH variation is not a compromising factor for aquatic life maintenance at sampling sites. According to ESTEVES (1998), most continental waterbodies present a pH that varies between 6 and 8.

High levels were found for the dissolved oxygen annual average at all monitored sites: P1: 8.65 mgO^2L^{-1}, P2: 8.93 mgO^2L^{-1} and P3: 8.28 mgO^2L^{-1}. The lowest recorded level was 7.1 mgO^2L^{-1}, in the month of December at P3, and the highest was 10.85 mgO^2L^{-1}, in the month of July at P2. These are expected levels for natural waters, being above expected levels expected by CONAMA resolution 357/2005 for class one waters, and do not constitute a compromising factor for the maintenance of aquatic biota at sampling sites. It is important to note the inverse relationship between the high levels of dissolved oxygen found at all three sites (Figure 4) in the month of July of 2023, with the low temperatures (Figure 2) recorded during the same month. Schäefer (1985) notes that oxygen balance must be understood as the single most important factor when evaluating an aquatic ecosystem. There were no statistically significant differences between the annual averages calculated for all three sites and the following parameters: temperature (ANOVA: Fcalc:1,28 ≤ Fcrit 3,44); Ph (ANOVA Fcalc: 2,437 ≤ Fcrit 3,44) and dissolved oxygen (ANOVA:Fcalc: 0,7958 ≤ Fcrit 3,44; α: 0,05).

Figure 5 shows the monthly variation for fecal coliform (*Escherichia coli*) at the SRWB ampling sites. Monitoring revealed a strong difference among the three sampling sites when taking CONAMA resolution 357/2005 into consideration. The resolution recommends a maximum count (4000 NMP/100ml) for this parameter. P1 and P2 presented counts that were always under the load established by the resolution. There was only one peak at P1 du-

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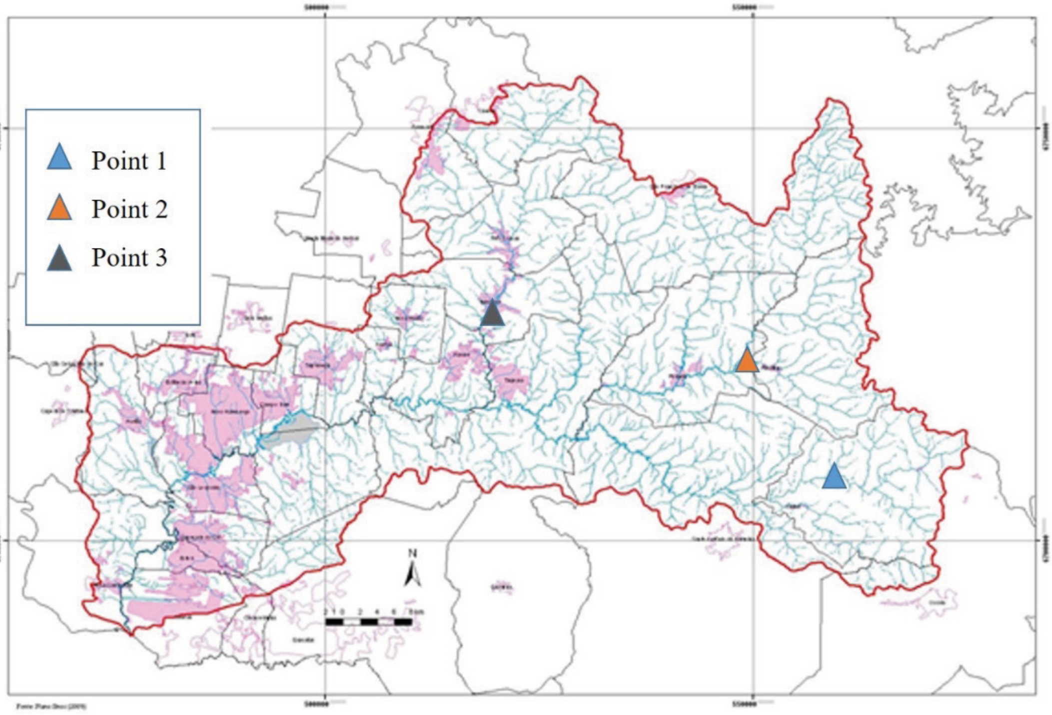

Figure 1. Location of the sampling sites (P1, P2 and P3), in the Sinos River Hydrographic Basin (SRHB), Southern Brazil, Rio Grande do Sul.

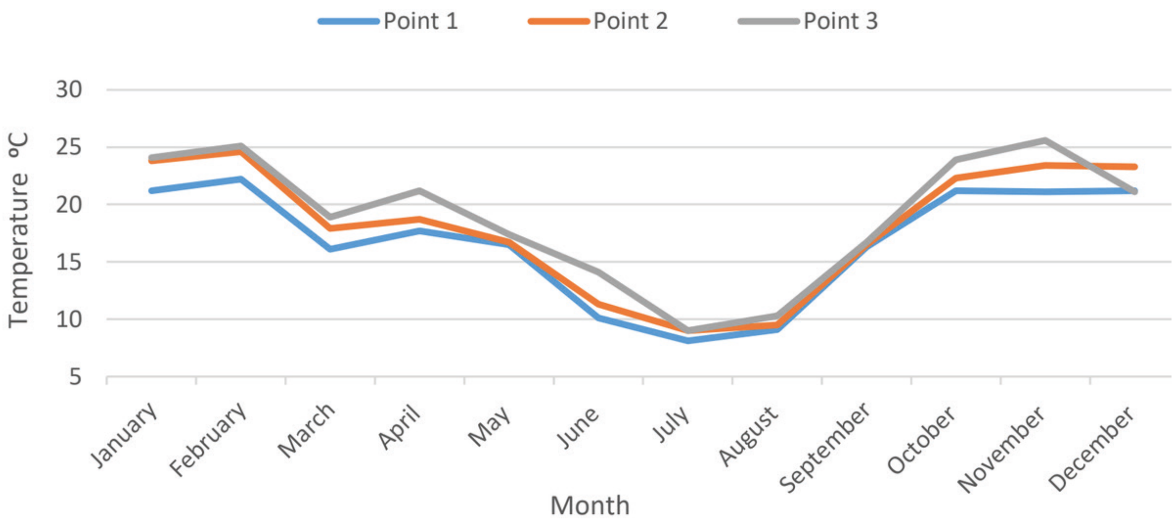

Figure 2. Variation in water temperature in the Sinos River Hydrographic Basin (SRHB), Southern Brazil, Rio Grande do Sul. (January-December 2023).

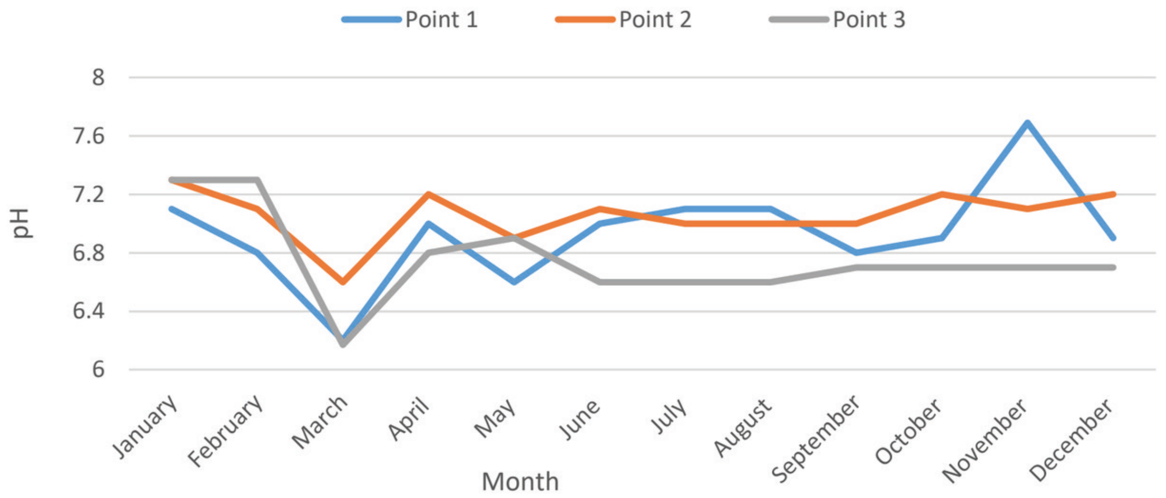

Figure 3. Variation in water pH in the Sinos River Hydrographic Basin (SRHB), Southern Brazil, Rio Grande do Sul. (January-December 2023).

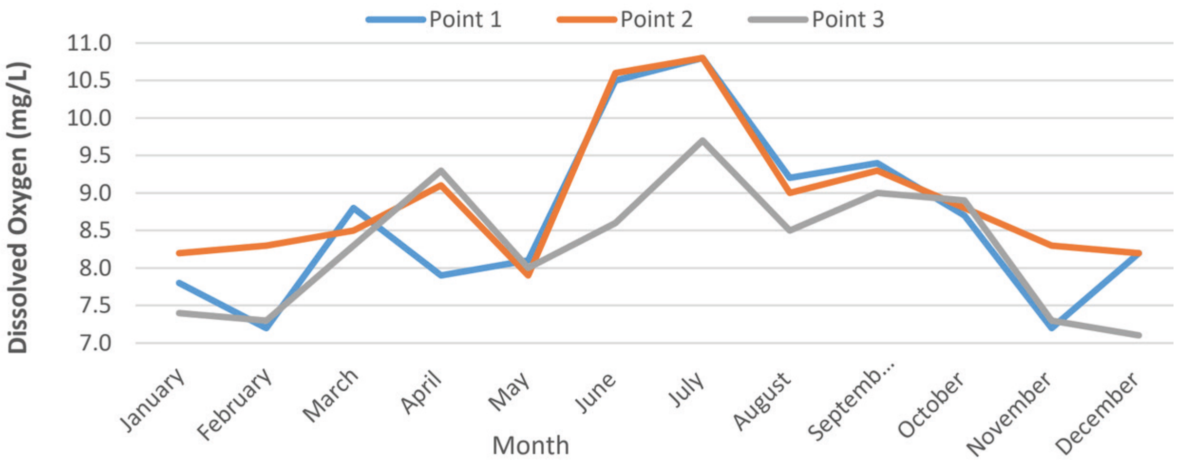

Figure 4. Variation in dissolved oxygen (mg/L) in the Sinos River Hydrographic Basin (SRHB), Southern Brazil, Rio Grande do Sul. (January-December 2023).

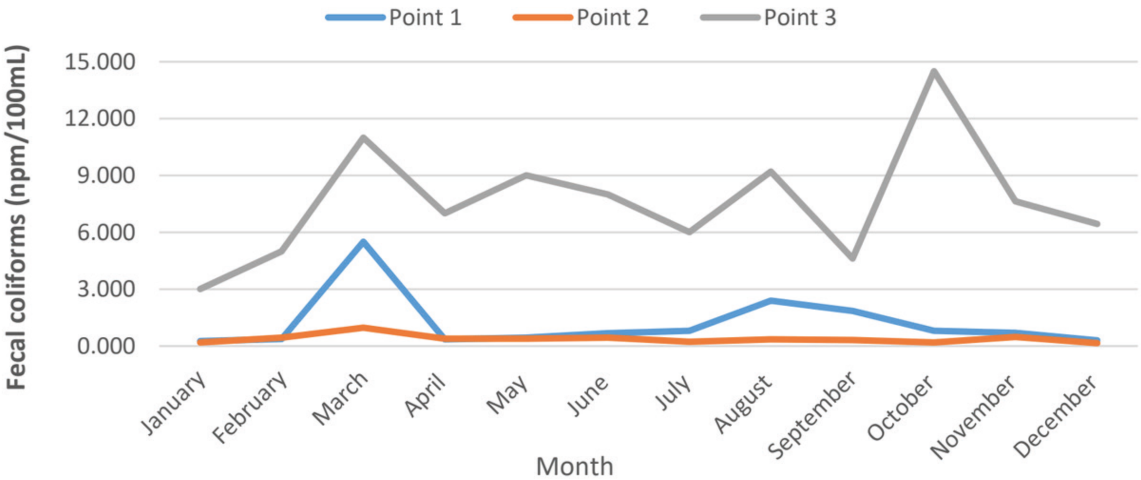

Figure 5. Variation in fecal coliforms (npm/100mL) in the Sinos River Hydrographic Basin (SRHB), Southern Brazil, Rio Grande do Sul. (January-December 2023).

Phylum/Class	**Order**	**Family**	**Score** BMWP **Sinos**	**P1**	**P2**	**P3**
Platyhelmintes	Tricladida	Dugesiidae	4	8	0	0
Platyhelmintes	Tricladida	Planariidae	3	0	0	1
Nematomorpha	Gordioidea	Gordiidae	2	0	0	1
Mollusca/ Gastropoda	Littorinimorpha	Hydrobiidae/Cochliopidae	3	0	68	54
Mollusca/ Gastropoda	Architaenioglossa	Ampullariidae	3	0	21	0
Mollusca/ Gastropoda	Hygrophila	Planorbidae	3	0	4	8
Mollusca/ Gastropoda	Hygrophila	Lymnaeidae	3	0	0	3
Mollusca/ Gastropoda	Hygrophila	Physidae	4	0	4	0
Mollusca/Bivalvia	Unionida	Hyriidae	8	1	2	0
Mollusca/Bivalvia	Unionida	Mycetopodidae	6	1	1	0
Mollusca/Bivalvia	Venerida	Corbiculidae (*Nl*)	4	0	23	154
Annellida/Oligochaeta	Haplotaxida	Haplotaxidae	2	0	0	1
Annellida/Oligochaeta	Tubificida	Tubificidae	2	0	4	0
Arthropoda/Chelicerata	Trombidiformes	"Hydracarina"	4	0	0	6
Arthropoda/Crustacea	Cladocera	Daphniidae	3	0	0	1
Arthropoda/Crustacea	Amphipoda	Hyalellidae	4	0	12	0
Arthropoda/Crustacea	Isopoda	Janiridae	7	0	1	0
Arthropoda/Crustacea	Decapoda	Aeglidae	8	56	0	0
Arthropoda/Crustacea	Decapoda	Palaemonidae	6	0	3	0
Arthropoda/Crustacea	Decapoda	Trichodactylidae	5	1	1	0
Arthropoda/Insecta	Hemiptera	Corixidae	4	0	1	0
Arthropoda/Insecta	Hemiptera	Gelastocoridae	6	0	1	0
Arthropoda/Insecta	Hemiptera	Naucoridae	3	0	16	15
Arthropoda/Insecta	Hemiptera	Veliidae	3	0	37	0
Arthropoda/Insecta	Hemiptera	Gerridae	3	0	1	0
Arthropoda/Insecta	Hemiptera	Nepidae	4	0	2	0
Arthropoda/Insecta	Hemiptera	Pleidae	3	1	0	0
Arthropoda/Insecta	Hemiptera	Notonectidae	4	0	1	0
Arthropoda/Insecta	Hemiptera	Mesoveliidae	3	0	1	0
Arthropoda/Insecta	Hemiptera	Belostomatidae	5	0	3	0
Arthropoda/Insecta	Coleoptera	Noteridae	6	3	0	0
Arthropoda/Insecta	Coleoptera	Scirtidae	7	2	0	0
Arthropoda/Insecta	Coleoptera	Ptilodactylidae	5	4	4	7
Arthropoda/Insecta	Coleoptera	Haliplidae	5	1	0	0
Arthropoda/Insecta	Coleoptera	Hydraenidae	5	1	8	0
Arthropoda/Insecta	Coleoptera	Elmidae	4	0	23	3
Arthropoda/Insecta	Coleoptera	Psephenidae	7	3	4	9
Arthropoda/Insecta	Coleoptera	Gyrinidae	2	5	1	0
Arthropoda/Insecta	Coleoptera	Staphylinidae	3	7	13	5
Arthropoda/Insecta	Coleoptera	Dytiscidae	2	3	0	0
Arthropoda/Insecta	Coleoptera	Hydrophilidae	2	4	0	4
Arthropoda/Insecta	Coleoptera	Dryopidae	3	1	0	0
Arthropoda/Insecta	Coleoptera	Lutrochidae	3	0	21	32
Arthropoda/Insecta	Diptera	Chironomidae	2	78	66	121
Arthropoda/Insecta	Diptera	Ceratopogonidae	2	45	4	34
Arthropoda/Insecta	Diptera	Tipulidae	4	9	29	0

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Arthropoda/Insecta	Diptera	Chaoboridae	2	0	0	5
Arthropoda/Insecta	Diptera	Dixidae	4	0	3	0
Arthropoda/Insecta	Diptera	Syrphidae	1	0	0	1
Arthropoda/Insecta	Diptera	Tabanidae	5	0	2	0
Arthropoda/Insecta	Diptera	Psychodidae	3	9	0	0
Arthropoda/Insecta	Diptera	Culicidae	2	0	2	3
Arthropoda/Insecta	Diptera	Simuliidae	4	35	28	0
Arthropoda/Insecta	Diptera	Empididae	4	1	4	1
Arthropoda/Insecta	Plecoptera	Perlidae	7	7	0	0
Arthropoda/Insecta	Plecoptera	Gripopterygidae	8	5	0	0
Arthropoda/Insecta	Megaloptera	Corydalidae	3	0	49	40
Arthropoda/Insecta	Megaloptera	Sialidae	5	13	1	1
Arthropoda/Insecta	Trichoptera	Philopotamidae	8	7	0	0
Arthropoda/Insecta	Trichoptera	Hydropsychidae	5	12	8	0
Arthropoda/Insecta	Trichoptera	Hydroptilidae	6	3	1	0
Arthropoda/Insecta	Trichoptera	Leptoceridae	10	3	0	0
Arthropoda/Insecta	Trichoptera	Glossosomatidae	8	4	67	0
Arthropoda/Insecta	Trichoptera	Polycentropodidae	7	7	8	0
Arthropoda/Insecta	Trichoptera	Calamoceratidae	6	2	0	0
Arthropoda/Insecta	Trichoptera	Odontoceridae	7	8	0	0
Arthropoda/Insecta	Trichoptera	Hydrobiosidae	7	78	7	0
Arthropoda/Insecta	Trichoptera	Helichopsychidae	7	8	7	0
Arthropoda/Insecta	Odonata	Gomphidae	6	9	55	75
Arthropoda/Insecta	Odonata	Corduliidae	4	7	9	0
Arthropoda/Insecta	Odonata	Coenagrionidae	4	44	8	67
Arthropoda/Insecta	Odonata	Megapodagrionidae	8	8	9	0
Arthropoda/Insecta	Odonata	Lestidae	1	2	2	2
Arthropoda/Insecta	Odonata	Aeshnidae	1	1	1	5
Arthropoda/Insecta	Odonata	Calopterygidae	5	7	11	0
Arthropoda/Insecta	Odonata	Perilestidae	5	4	13	24
Arthropoda/Insecta	Odonata	Libellulidae	6	1	12	0
Arthropoda/Insecta	Odonata	Dicteriadidae	5	23	2	0
Arthropoda/Insecta	Ephemeroptera	Leptohyphidae	3	35	122	145
Arthropoda/Insecta	Ephemeroptera	Baetidae	3	31	106	114
Arthropoda/Insecta	Ephemeroptera	Leptophlebiidae	6	5	8	0
Arthropoda/Insecta	Ephemeroptera	Caenidae	2	0	2	0
Arthropoda/Insecta	Lepidoptera	Pyralidae	5	21	65	0
Total Family Richness		**83**				
TOTAL/ind./point				**634**	**992**	**942**
TOTAL/individual					**2,568**	
TOTAL/family/point				**50**	**59**	**31**
å BMWP/point				**253**	**262**	**102**

Table 2. Taxonomic list, BMWP $_{\text{Sinos Index}}$ and absolute frequencies for benthic macroinvertebrates with recorded families by sampling site between January and December of 2023. P1 - (29°45’45”S/50°19’37”W) City of Caraá; P2 - (29°38’34”S/50°32’33”W) City of Rolante; P3 - (29°36’10”S/50°48’49”W) City of Igrejinha – Score according to Mandaville 2002 and IAP, 2003 adapted for the SRWB.

ring the month of March (5500 NMP/100ml). Except during the month of January of 2023, P3 always presented higher counts than the ones established by the CONAMA resolution, with a maximum 14500 NMP/100ml (October/2023). This shows high levels of contamination which come from the cities where River Paranhana runs through, such as Três Coroas, Gramado, Canela and São Francisco de Paula.

COMMUNITY BIODIVERSITY, STRUCTURE AND COMPOSITION AND THE $BMWP_{SINOS\ INDEX}$

A total of 2,568 individuals, including immature individuals, were collected during sampling period. From the total, 634 specimens were sampled at Point 1 (Caraá), 992 were sampled at Point 2 (Rolante) and 942 were sampled at Point 3 (Igrejinha). A total of 83 families were found for the basin, of which four did not present values to calculate the $BMWP_{Sinos\ Index}$ using the adapted table for the state of Paraná (IAP, 2003), such as Ampullaridae (Mollusca), Cymothoidae (Crustacea), Staphilinidae and Lutrochidae (Insecta). Scores were given to the families based on their frequency and biology. Scores may be found at Table 2.

BMWP-Sinos scores by can be found at Table 1. Annual average calculated sums (P1 = 253, P2 = 262 and P3 = 102) classify water as unpolluted at the first two sites and very polluted waters at the third site. This means that the waters and clean and not polluted and waters with pollution respectively. Recorded values have a direct relationship with the recorded richness of families each sampling site (P1 = 50, P2 = 59 and P3 = 31). MONTEIRO et al. (2008) also note that low water quality at river sources located in the Meia Ponte River Basin, in the state of Goiás, were detected by the use of BMWP. This was associated by other authors to an intense monetary activity and agriculture in that region. There is a clear indication of waterbody degradation at Site 3. This indicates a different environmental impact, probably originating from the cities where the Paranhana River runs through, such as Três Coroas, Gramado, Canela and São Francisco de Paula.

Benthic macroinvertebrate species are differentially sensitive to many biotic and abiotic factors in their environment, consequently, macroinvertebrate community structure has commonly been used as an indicator of the condition of an aquatic system (BARROS et al., 2016).

The SRWB has been affected along its longitudinal course by different polluting sources, which can be evidenced by biomonitoring benthic macroinvertebrates. The presence of families that show environmental impact (more sensitive) was compromised, especially closer to the site that is located near the urban environment. The Paranhana river shows the highest impact in the upper-middle course of the SRWB and significantly contributes towards water deterioration; from the city of Taquara on, the water quality for maintenance of the biota is compromised, as well as the quality of water supplied to the population. It is commonly reported that lotic water systems are considerably loaded with domestic sewage and industrial waterwaste in highly urbanized areas. This accelerates the eutrophication process and the reduction of dissolved oxygen, creating and effect on the biota. Is this particular situation, the dissolved oxygen levels have always been higher than legally established patterns, not constituting a compromise towards the maintenance of aquatic life. Sites 2 and 3 showed similar results, with positive evaluations for the quality of monitored waterbodies regarding maintenance of aquatic biota as well as the integrity of water for public supply. Changes in the integrity of a waterbody can be followed in a long term basis with a monitoring program that uses different tools, such as biotic and chemicalindexes. Aquatic organisms, especially benthic macroinvertebrates, constitute one of the biological parameters that can reflect the health of an aquatic system, mainly because they are found in certain locations. One of the most evident results found in environments which have suffered impact is the reduction of biodiversity. Other ecological groups, such as zooplankton, can also be used to perform an integrated evaluation of ecological effects caused by multiple pollution sources in continental environments. Thus, the present study emphasizes the practice of performing an integrated environmental evaluation for better understanding the function of anthropic ecosystems, such as the Sinos River Water Basin.

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