Microplastics pollution in the South American Pantanal

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Microplastics represent an emerging global threat to freshwater ecosystems and studies in floodplains are still incipient. Microplastics in the Pantanal's affluent and floodplains were sampled close to their potential urban sources and in the Pantanal lowlands. A 68 µm mesh size plankton net, with a 150 ml collection flask was used for sampling. The flask content was filtered over a 0.45µm Whatman paper, 47 mm in diameter, and examined under a stereomicroscope at 45X to identify and count microplastics (expressed as $n100L^{-1}$). Microplastic sizes were determined by image microscopy. The average microplastic size was 192±142 µm and it was not significantly different in the urban tributaries (206±158 µm) than in the Pantanal (181±131 µm). The average±std microplastic concentration was 9.6±8.3, ranging from 1 to 31 $n100L^{-1}$. Fibers, fragments, pellets, and XPS (closed-cell extruded polystyrene foam) particles represented respectively 50%, 19%, 22% and 9% of the total microplastics. Microplastics concentrations were higher in the urban tributaries (19.9±5.8 $n100L^{-1}$) than in the Pantanal lowlands (4.5±2.5 $n100L^{-1}$). Fibers were always the most important fraction, followed by fragments. In the lowlands, pellets were scarce and XPS were absent. Comparison between microplastic composition in the floodplain and the urban areas suggest that pellets are transported from the urban area to the Pantanal, while microfibers and fragments could both be transported from the urban areas and have a local origin. These results indicate that microplastics are contaminating the Pantanal and its affluents and eventually can affect the local fauna. More research is needed to understand the extent and possible implications regarding the contamination by microplastics of the aquatic and terrestrial ecosystems of the Pantanal.

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Abstract

Microplastics represent an emerging global threat to freshwater ecosystems and studies in floodplains are still incipient. Microplastics in the Pantanal's affluent and floodplains were sampled close to their potential urban sources and in the Pantanal lowlands. A 68 µm mesh size plankton net, with a 150 ml collection flask was used for sampling. The flask content was filtered over a 0.45µm Whatman paper, 47 mm in diameter, and examined under a stereomicroscope at 45X to identify and count microplastics (expressed as $n100L^{-1}$). Microplastic sizes were determined by image microscopy. The average microplastic size was 192±142 µm and it was not significantly different in the urban tributaries (206±158 µm) than in the Pantanal (181±131 µm). The average±std microplastic concentration was 9.6±8.3, ranging from 1 to 31 $n100L^{-1}$. Fibers, fragments, pellets, and XPS (closed-cell extruded polystyrene foam) particles represented respectively 50%, 19%, 22% and 9% of the total microplastics. Microplastics concentrations were higher in the urban tributaries (19.9±5.8 $n100L^{-1}$) than in the Pantanal lowlands (4.5±2.5 $n100L^{-1}$). Fibers were always the most important fraction, followed by fragments. In the lowlands, pellets were scarce and XPS were absent. Comparison between microplastic composition in the floodplain and the urban areas suggest that pellets are transported from the urban area to the Pantanal, while microfibers and fragments could both be transported from the urban areas and have a local origin. These results indicate that microplastics are contaminating the Pantanal and its affluents and eventually can affect the local fauna. More research is needed to understand the extent and possible implications regarding the contamination by microplastics of the aquatic and terrestrial ecosystems of the Pantanal.

Introduction

Microplastics (<5mm diameter) are reported in lakes and watercourses in all continents (Wagner, Scherer et al. 2014, Eerkes-Medrano, Thompson et al. 2015, Horton, Walton et al. 2017, Lebreton, van der Zwet et al. 2017, Lambert and Wagner 2018). Therefore, even if the number of surveyed water bodies is still relatively small and studies specific to floodplains incipient, they are probably ubiquitous to every continental aquatic habitat. Present knowledge is still insufficient to link sources, transport pathways, and the fate of microplastics in freshwater environments (Schmidt, Krauth et al. 2017). Microplastic modeling studies of transport along watercourses suggest that floodplains are likely to act as sinks or sources depending on the hydrodynamics of water sources and the properties of floodplain aquatic or terrestrial environments (Nizzetto, Bussi et al. 2016, Besseling, Quik et al. 2017, Horton, Walton et al. 2017, Horton Alice and Dixon Simon 2017, A. and J. 2018, Kooi, Besseling et al. 2018). In river basins, cities are probably the main sources of microplastics, and particle transport is a function of distance from the source (Wang, Ndungu et al. 2017), water flow velocity and particle size (Besseling, Quik et al. 2017), similar to other suspended solids.

Current studies show that exposure of the biota to microplastics trigger a wide variety of responses from feeding disruption to reproductive performance, physical ingestion, disturbances in energy metabolism, changes in liver physiology from lower to higher trophics (Anbumani and Kakkar 2018). Also, there is a growing body of evidence indicating that microplastics interact with terrestrial organisms that mediate essential ecosystem services and functions, such as soil-dwelling invertebrates, terrestrial fungi, and plant-pollinators. Therefore, microplastic pollution might represent a global threat to terrestrial/continental ecosystems (de Souza Machado, Kloas et al. 2018) of equal magnitude to coastal and marine ecosystems.

Studies in floodplains and wetland environments reported microplastics in Europe, China, North and South America. Scheurer and Bigalke (2018) found evidence that 90% of Swiss floodplain soils contain microplastics. They are reported in the Danube Alluvial Zone National Park, preserving the last major wetlands in central Europe (Lechner, Keckeis et al. 2014). They are also found in urban estuaries in China, (Zhao, Zhu et al. 2015) and in some affluents of lake superior, such as the Nemadji and Saint-Louis rivers that run through wetlands complexes (Baldwin, Corsi et al. 2016). In Brazil, microplastics were reported in the shoreline sediments of a lake of the Paraná River Floodplain (Blettler, Ulla et al. 2017) and in the upper, the middle and lower portion of the Goiana Estuary (Lima, Costa et al. 2014, Lima, Barletta et al. 2015). In this estuary, microplastics contaminated the life cycle of Acoupa weakfish (*Cynoscion acoupa*) (Ferreira, Barletta et al. 2016). Microplastics were also found to be ingested by *Hoplosternum littorale*, a common freshwater fish heavily consumed by humans in South America (Silva-Cavalcanti, Silva et al. 2017).

The Pantanal, a monomodal pulsing wetland system larger than England, is known for its mega biodiversity and for providing diverse environmental services (Wantzen, da Cunha et al. 2008) and this was made explicit by the Brazilian Constitution which recognized the Pantanal as a "National Heritage", by the Ramsar Convention which listed it as a Wetland of International Importance and it was designated as Biosphere Reserve by the UNESCO in 2000 (Harris, Tomas et al. 2005).

The aim of this paper is to report water contamination by microplastics in the Pantanal wetlands and affluent. The main hypothesis is that microplastics are transported in the Pantanal from their likely urban sources. To verify this hypothesis, the variation in microplastics concentrations from the urban tributaries of the Cuiabá River in Cuiabá City and from the Pantanal wetlands was analyzed. The Cuiabá River is the second largest affluent of the Pantanal (Girard, Fantin-Cruz et al. 2010) and one of the most studied Pantanal tributaries.

Material & Methods

The Pantanal wetlands. The Pantanal (*Fig. 1*) is a large mosaic of wetlands of ~160,000 km^2 in the center of South-America within the Upper Paraguay Basin -UPRB- (Girard 2011). Its hydrological cycle is characterized by a monomodal, predictable, annual flood pulse. The flooding dynamics along with the geomorphological heterogeneity generate a diversity of macrohabitat sustaining large biodiversity. Flora and fauna species from the surrounding savanna dominate, but species from the Amazon, Chaco, and dry forest biomes are also present as well as are very few endemic species. At present, the main factors responsible for changes in the

Pantanal ecosystems include the construction of hydroelectric dams along the headwaters, changing the natural flood regime, increased sediment input from upland agroindustries into the rivers, pollution by agrochemicals, mercury input from gold mining, and liquid and solid wastes discharged by cities along the rivers entering the Pantanal (Junk and Nunes da Cunha 2016).

The Cuiabá River is one of the most important tributaries of the Paraguay River and contributor to the Pantanal wetland system. Its headwaters are located in the *planalto* region, with heights between 350m and 850m. The mid-river reach flow through the Precambrian Depression zone of the Cuiabá lowlands (350–150 m). On its margin, the cities of Cuiabá and Várzea Grande were built. Many small tributaries are born within this metropolitan agglomeration. These small streams and brooks flow through urban areas and reach the Cuiabá main channel. The metropolitan area is home to about 864 000 persons for a density of about 200 inhabitants km^{-2} (IBGE 2017) In Cuiabá, 30% of the wastewater is collected and treated by the municipality, 23% collected and treated by the households or commerce/industry and 47% is not collected nor treated. In Várzea Grande, these figures are 17%, 28%, and 55% respectively (ANA 2017). The river average annual discharge at Cuabá city is 386 $m^3 s^{-1}$ (Girard 2011). Downstream from Cuiabá metropolitan area, the river flows pass Santo Antônio de Leverger, home to about 18 000 persons (1.51 inhabitant km^{-2}) with only 10.4% of wastewater adequately treated (IBGE 2017). The river then enters the Pantanal floodplain (<150 m) (Assine and Soares 2004) and flows in an area of very low population density with some settlements such as Porto Cercado (Pott and Pott 2004, Junk and Cunha 2005).

The regional climate is tropical sub-humid with an average temperature of 25ºC and a mean annual rainfall 1400mm at Cuiabá and Várzea Grande, 80% of which falls between November and April. Thus, flood (high water) period usually peaks in March-April. Droughts usually occur in September, during the dry season (May-October). The estimated time lag between the city of Cuiabá and the response of flooding levels in the northern part of the Pantanal is about 4 weeks (Zeilhofer and de Moura 2009).

Sampling sites. The following samples were collected during the flood period. Two urban tributaries of the Cuiabá River in the Cuiabá city were sampled in March 2018. In April 2018, four locations in the Pantanal lowlands close to Porto Cercado were also collected. These locations were sampled 5 times each (*Table 1*).

Microplastics Sampling and Analysis. The method suggested by Arruda, Diniz et al. (2017) to collect plankton was adapted to insured that sampling could also be carried by the plankton study team. In the Pantanal, all samples were obtained from a boat and conducted at about 40 cm below the water level. The vessel was not anchored and all ropes were kept apart from sampling apparatus Only cotton wear was used when sampling was performed. In the Cuiabá river tributaries, surface samples were taken.

A plankton net of 30 cm of diameter, 70 cm length, 68 µm mesh size with a 150 ml collection flask was used to sample microplastics following a methodology used in the Greater Paris area by Dris, Gasperi et al. (2015). The plankton net was used because the water bodies sampled in this study were shallower than coastal and oceanic areas where a neuston net is usually used. A plankton net was deemed more appropriate to collect in the Pantanal region, were small urban rivers and small inland lakes were to be sampled. Furthermore, using a smaller mesh size allows capturing more microplastics as well as sizes relevant for predators (Lehtiniemi, Hartikainen et al. 2018). Once the sample was acquired, water samples were poured directly into a glass filtration apparatus (Buchner funnel and vacuum flask) and vacuum pumped through a 0.45 μm filter (Whatman mixed cellulose nitrate, 47 mm diameter) (Barrows, Neumann et al. 2017).

Once the samples were filtered, the filters were allowed to dry covered to minimize airborne contamination. They were then examined at 45X magnification under a Zeiss stereo microscope to identify and count microplastics. The same operator performed all the observations. To distinguish synthetic from biological fibers, the criteria of Dris, Gasperi et al. (2015) was used. Microplastics were categorized on the base or their shape and/or material: fibers, pellets (spherules), closed-cell extruded polystyrene foam (XPS), and fragments which included all that was not from the first three categories. A similar categorization was used by Mani et al. (2015) and Wang et al. (2017). Results are reported in the number of microplastic particles per 100 liters ($n100L^{-1}$).

The size of the sampled microplastics particles was also determined. For each sample (each filter), 5 microplastic particles were chosen at random for size determination. When there were 5 or fewer particles, all particles were measured using image microscopy. For spherical (or quasi-spherical) particles, the diameter was measured. When the particle was not spherical, the long and short axes were measured. As 99% of the short axis measurements were < 68 μm, the long axis was used to characterize the particle size. A total of 125 microplastic particles were measured.

To minimize the potential for cross-contamination between sample sites and sample campaigns the following procedure was adopted. Before each campaign, the plankton net was thoroughly washed. The collection flask and sampling bottles were rinsed 3 times (totally filled and then emptied). At all sampling location, the plankton net was washed with the equivalent of 3 times its volume with the local water. The collection flask and sampling bottles were rinsed 3 times with local water. On coming back from one sampling campaign the plankton net and collection flask were washed thoroughly.

To assess potential contamination from laboratory containers or air, ten laboratory blanks were collected and analyzed alongside the environmental samples. They consisted of distilled water stored in open sample containers for periods of 5 days. One microplastic fiber was found in one of the blanks, indicating low contamination potential from within the laboratory.

MS-Excel was used for data tabulation and calculation. Student *t*-tests (and preceding F-tests) were used to compare averages between location. The Excel Data Analysis Tool was used to perform these tests.

Results & Discussion

Microplastics concentrations. The microplastics concentrations ($n100\ L^{-1}$) range from as low as 1 in the flooded fields of the Pantanal up to 31, in an urban tributary of the Cuiabá River in Cuiabá city. The average concentration of microplastics in the study area is 9.6±8.3 $n100\ L^{-1}$.

Fibers make the most of the microplastic load, accounting for 50% of the particles, followed by fragments (19%), pellets (22%) and XPS (9%) (*Fig. 2*). The average concentration found in the study area falls within the range of concentrations observed in rivers and estuaries across the globe (Lima, Barletta et al. 2015, Zhao, Zhu et al. 2015, (Dris, Gasperi et al. 2015, Lebreton, van der Zwet et al. 2017). They are three orders of magnitude greater than those reported for the Goiana Estuary where a maximum value of 14 microplastics 100m^{-3} (0.014 particles 100L^{-1}) (Lima, Barletta et al. 2015) or comparable to what was found in urban estuaries in China where concentrations range from 100 to 4.100 particles m^{-3} (10 to 410 n100L^{-1}) (Zhao, Zhu et al. 2015) or in the Greater Paris also area (also collected with a plankton net) where the mean concentration was 30, ranging from 3 to 106 particles m^{-3} (0.3 to 10.6 n100L^{-1}) (Dris, Gasperi et al. 2015). In a global survey of microplastics in rivers, average concentrations were found to vary over 5 orders of magnitude ranging from 3.69×10^{-2} to 4.14×10^{3} particles m^{-3} (3.69×10^{-3} to 4.14×10^{2} n100L^{-1}) (Lebreton, van der Zwet et al. 2017).

There are more than 4 times more microplastics in the urban tributaries of the Cuiabá River than in the Pantanal (*Fig. 1*). In the Cuiabá urban area, the average microplastic concentration is 19.9 ±5.8 n100L^{-1} (*Fig. 2*). The samples were collected during the high waters/rainy season 2018. At this moment, washing of the heavily urbanized watershed of the urban tributaries by heavy rains might well draw microplastics to their channels and surface runoff could likely be the main source of microplastics (Baldwin, Corsi et al. 2016, Horton, Svendsen et al. 2017). Higher microplastics concentrations were also observed closer to their sources on the Rhine (Mani, Hauk et al. 2015), in tributaries of the Great lakes (Baldwin, Corsi et al. 2016), in lakes of Wuhan, China (Wang, Ndungu et al. 2017), as population densities and urbanization are associated with the input of microplastics in surface waters (Lebreton, van der Zwet et al. 2017).

Fibers (8.1±4.0 n100L^{-1}) are the most important category in the urban tributaries of the Cuiabá River, (*Fig. 1* and *Fig. 2*). Washing sewage is a likely source of fibers in urban areas (Browne 2015). In inland waters as well as urban estuaries in China, fibers were also the most frequently detected form of microplastics. There, household sewage (clothes washing) may be the most important source of microfibers followed by fishing (Zhao, Zhu et al. 2015, Wang, Ndungu et al. 2017). These are also likely sources for microfibers in the Cuiabá River tributaries.

Pellets (6.0±3.5 n100L^{-1}) are the second most important category of microplastic in the urban Cuiabá area (*Fig. 1* and *Fig. 2*). Pellets might come from personal care products or material used for construction, furniture, paints, lighting, and electronics as well possibly originating from the plastic waste that manufacturers washed into the water treatment systems as found in the Rhine river (Mani, Hauk et al. 2015).

Fragments average concentration is 3.2±3.1 n100L^{-1} in the urban tributaries. In the Thames river sediments, fragment particle types make up to 47.4% of the microplastics. There, fragments were associated with locally-derived secondary microplastics (Horton, Svendsen et al. 2017), which is likely to be the source in the urban tributaries of the Cuiabá river. Finally, XPS particles are only encountered in the Cuiabá river tributaries. Their average concentration is 2.6±4.5 n100L^{-1}.

Microplastic sizes. The average size of microplastic particles in the Pantanal region is 192±142 µm, ranging from 13 to 632 µm (*Fig. 3*). Note that 20% of the measured particles are < 68 µm. This is frequently observed when collecting phytoplankton and is due to partial clogging of the net by organic matter during sampling.

Microplastics concentrations related in the literature are typically obtained using a net with a mesh size of 300 µm (Lebreton, van der Zwet et al. 2017). Considering that only 20% of the microplastics size distribution in the present study are > 300 µm, it is possible to assume that if a 300 µm mesh net would have been used, the average concentration found would have been a fifth of what it was found to be with a plankton net. This estimated concentration, 1.92 $n100L^{-1}$, is still within the range of what is observed globally.

In the Cuiabá urban area, the average microplastic size is 206±158 µm and not significantly different than the average of 181±131 µm (t = -0.90; p = 0.38) obtained in the Pantanal wetlands. (*Fig. 3*) In the Cuiabá urban tributaries, the average size of fibers and fragments is 273±144 µm and 105±74 µm, respectively. The average size of the microsphere particles was 43±61 µm. However, their median size is 20 µm. The difference is due to a single pellet of 166 µm (*Fig. 3*). However, personal care products microbeads are usually > 200 µm (Chang 2015), while microplastics from sources such as painting and coating use smaller sizes, around 20 to 40 µm (Szabó, Molnár-Nagy et al. 2011). Pellets of this size indicate that in the Cuiabá urban area, industrial sources are more likely than personal care products for pellets. There are only two size measurements for XPS particles: 80 and 532 µm. In the study area, XPS is widely used for packaging food and also to carry meals. Once discarded these could be a source of secondary microplastics.

Sources of microplastics in the Pantanal lowlands. Within the Pantanal lowlands, microplastics average concentration is 4.5±2.5 n100 L^{-1} significantly different than in the Cuiabá River urban tributaries (t = 10.23; p = 5.82×10^{-11}) (*Fig. 1* and *Fig.2*). In the Pantanal, the population density is very low (Pott and Pott 2004, Junk and Cunha 2005), and economic activity restricted mostly to extensive cattle ranching, fisheries, and tourism (Wantzen, da Cunha et al. 2008). Plastic waste from these activities constitutes a potential local source of microplastics (Ferreira, Barletta et al. 2018, Xiong, Zhang et al. 2018). Alternatively, or concurrently, microplastics might be transported by the Cuiabá River into the Pantanal from the Cuiabá urban area.

The most striking difference in microplastic composition between the Cuiabá area and the Pantanal is the absence of XPS and the very low average concentration of pellets (0.1±0.3 $n100L^{-1}$) (*Fig. 2*). As in the Cuiabá urban area, pellet size is around 20 mm (*Fig. 3*), likely indicating an industrial source. As there are no such industries in the Pantanal, transport from the Cuiabá urban area into the Pantanal is a most likely source.

In the Pantanal, the average microfiber concentration was 3.2±2.5 $n100L^{-1}$. These might origin from local sources such as tourism and fisheries. As pellets, fibers concentration is lower in the Pantanal than in the Cuiabá urban area and this could indicate that transport from the cuiabá metropolitan also likely contributed to the fiber aqueous load. However, pellets concentration are

60 times lower in the Pantanal floodplain than in the Cuiabá urban area, while this ratio is about 2.6 for fibers which suggest that local fibers might have contributed to the fibers load in the Pantanal (*Fig. 2*). Such uncertainty relative to fiber sources was also encountered in the Great Lakes tributaries (Baldwin, Corsi et al. 2016).

The average concentration of fragments (1.2±1.1 $n100L^{-1}$) is also lower in the Pantanal than in the urban area by a factor of about 2.7. Plastic waste from tourism is a likely source of secondary micro-fragments (Xiong, Zhang et al. 2018), but, as for microfibers, transport from the urban area cannot be ruled out as a potential source.

Studies show that microplastics might be retained by river sediments along their course from their input points, causing concentrations to decrease away from the source (Wang, Ndungu et al. 2017, Kooi, Besseling et al. 2018). Particle deposition on floodplains might also result in concentration differences (Horton, Walton et al. 2017, Bläsing and Amelung 2018, Scheurer and Bigalke 2018). During high waters, the Cuiabá river invades the floodplains and there the current velocity is quite lower than in the main river channel. As an indication, at Porto Cercado, the mean current velocity measured in the floodplain in 2007 was 0.14 ms^{-1} while in the mean channel it was 0.64 ms^{-1} (Girard, Fantin-Cruz et al. 2010, Fantin-Cruz, Pedrollo et al. 2011). Such a drop in current velocity is likely to provoke deposition of microplastics (Nizzetto, Bussi et al. 2016, Nel, Dalu et al. 2018).

Evidence that floodplains sediments and soils contain microplastics were found in several locations. For example, in the shoreline sediments of a lake of the Paraná River Floodplain in Brazil, microplastics microplastic particles (diverse resins) were recorded (Blettler, Ulla et al. 2017). In another study in Switzerland, 90% of Swiss floodplain soils were found to contain microplastics probably supplied from diffuse sources in river water or through aeolian transport (Scheurer and Bigalke 2018).

Simulations regarding hydrological control on the storage of larger and heavier particles within the stream system indicate that size (rather than density) appears to be a more sensitive parameter influencing the transport dynamics of microplastics (Nizzetto, Bussi et al. 2016, Besseling, Quik et al. 2017). This suggests that a certain size range is more likely to be transported. In this study, particle size distribution is about the same in the Cuiabá River urban tributaries and in the Pantanal waters. The microfibers (making half of the microplastics load) size range is wider in the Pantanal than in the urban area (*Fig. 3*), which could indicate that both local sources and transport might be contributing microfibers in the Pantanal.

Conclusions

Microplastics were found in urban upland tributaries which are flowing in the urban area of Cuiabá city, the capital of Mato Grosso and within the Pantanal lowlands. Fibers are the most important microplastics both in the urban tributaries and in the Pantanal. The main source of microfibers in the urban tributaries of the Cuiabá River appears to be washing sewage and these particles are likely to be transported downstream in the Pantanal. However, tourism and fisheries are also likely sources in the Pantanal and the relative importance of these sources of microfibers in the Pantanal is still unknown. Comparison between microplastic composition in the floodplain and the urban areas suggest that pellets origin from industries and are transported from the urban area to the floodplain. Micro fragments in the Pantanal appear to be derived from secondary sources such as plastic wastes from tourism and fisheries, but transport from the Cuiabá city urban area is also a likely source.

Microplastics from the Cuiabá city urban area are likely contaminating the Pantanal and eventually can affect the local fauna. More research is needed to understand the extent and possible implications regarding the contamination by microplastics of the aquatic and terrestrial ecosystems of the Pantanal.

Next studies should aim to expand the sampling area to the entire Pantanal. As it is likely that microplastic might deposit in the floodplain, their concentrations in the soils and sediments of the floodplains, as well as channel sediments, should also be determined. Studies on microplastics contamination of the local fauna are needed as well.

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Figure 1

Study area and microplastics in the Pantanal.

The lower left inset shows the location of the UPRB in South America. The upper left inset shows the Pantanal within the UPRB. The main figure shows the Cuiabá River with locations mentioned in the text and the two sampling locations. Also shown are the average microplastics concentrations (n100 L^{-1}) and compositions in the tributaries of the Cuiabá River in the city of Cuiabá and the Pantanal Lowlands (smallest pizza). The pizza size is proportional to the average concentration of total microplastics at each location shown in bold italic below the pizza. The numbers associated with pizza slices are the average concentrations for each category at that location. Geographic map layout modified from Paz, Bravo et al. (2010).

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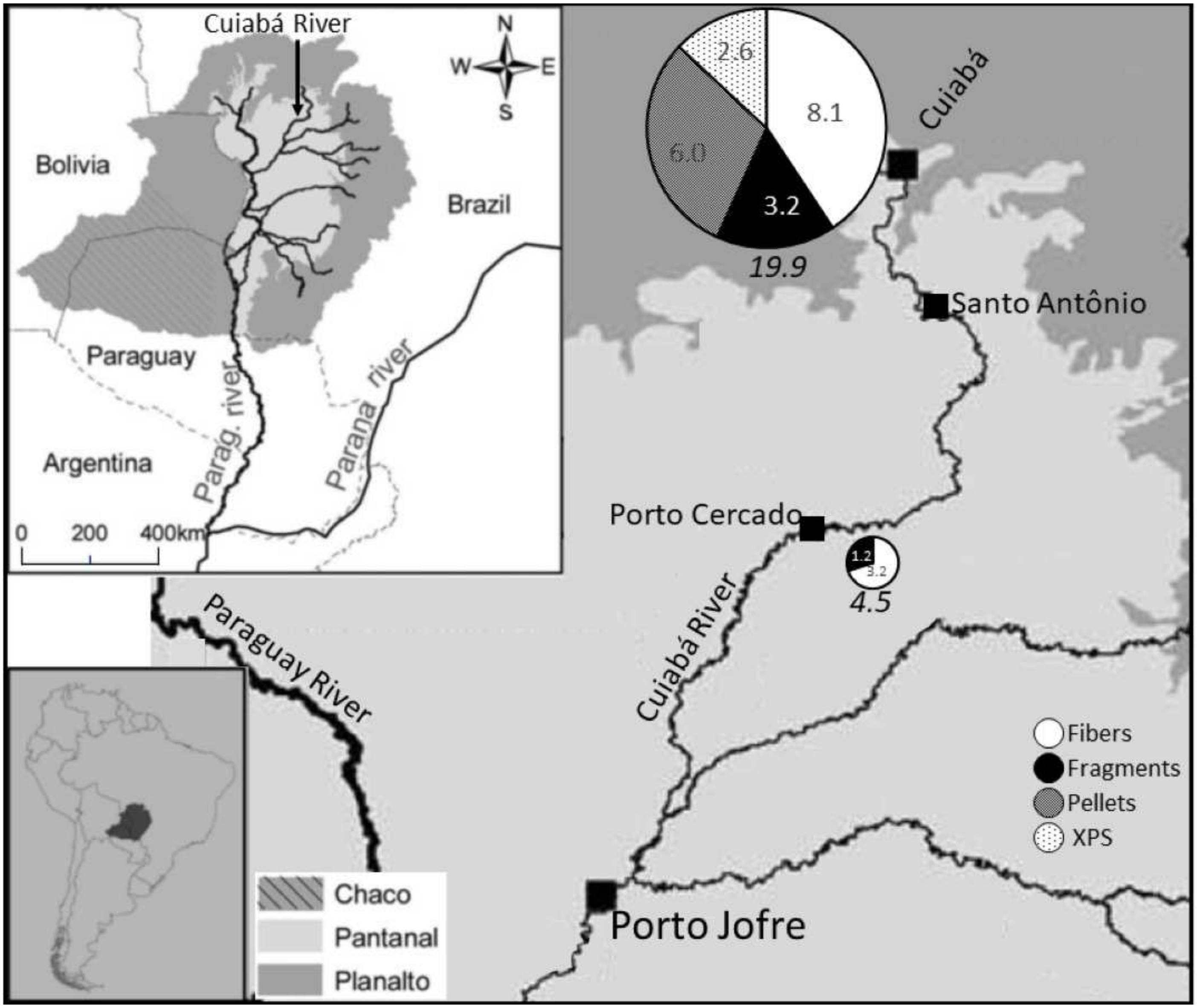

Cuiabá River
N
W
E
S
Bolivia
Brazil
Paraguay
Parag. river
Parana river
Argentina
0 200 400km
2.6
8.1
6.0
3.2
19.9
Cuiabá
Santo Antônio
Porto Cercado
1.2
3.2
4.5
Paraguay River
Cuiabá River
Fibers
Fragments
Pellets
XPS
Chaco
Pantanal
Planalto
Porto Jofre

Figure 2(on next page)

Microplastic composition.

C.R stands for Cuiabá River. N for Study area, C. R. urban tributaries and Pantanal is 30, 10, 20, respectively.

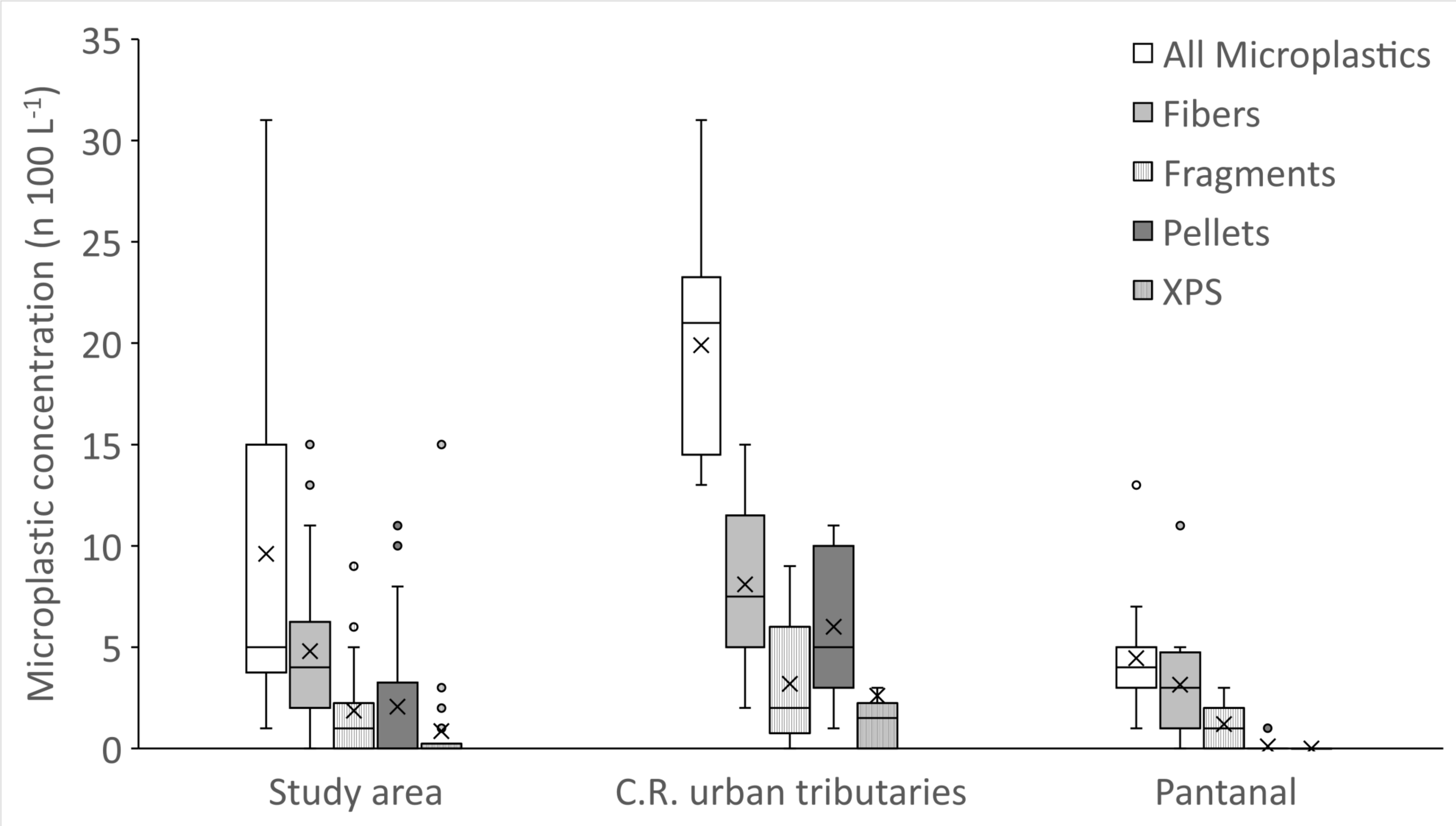
Microplastic concentration (n 100 L-1)
35
30
25
20
15
10
5
0
All Microplastics
Fibers
Fragments
Pellets
XPS
Study area
C.R. urban tributaries
Pantanal

Figure 3 (on next page)

Microplastic sizes in the Cuiabá River tributaries and in the Pantanal.

Sample sizes as follow total N (N in C.R. Tributaries, N in the Pantanal): all microplastics 125 (50, 75); fibers 83 (30; 53); fragments 32 (12, 20), pellets 8 (6, 2); XPS 2 (2, 0).

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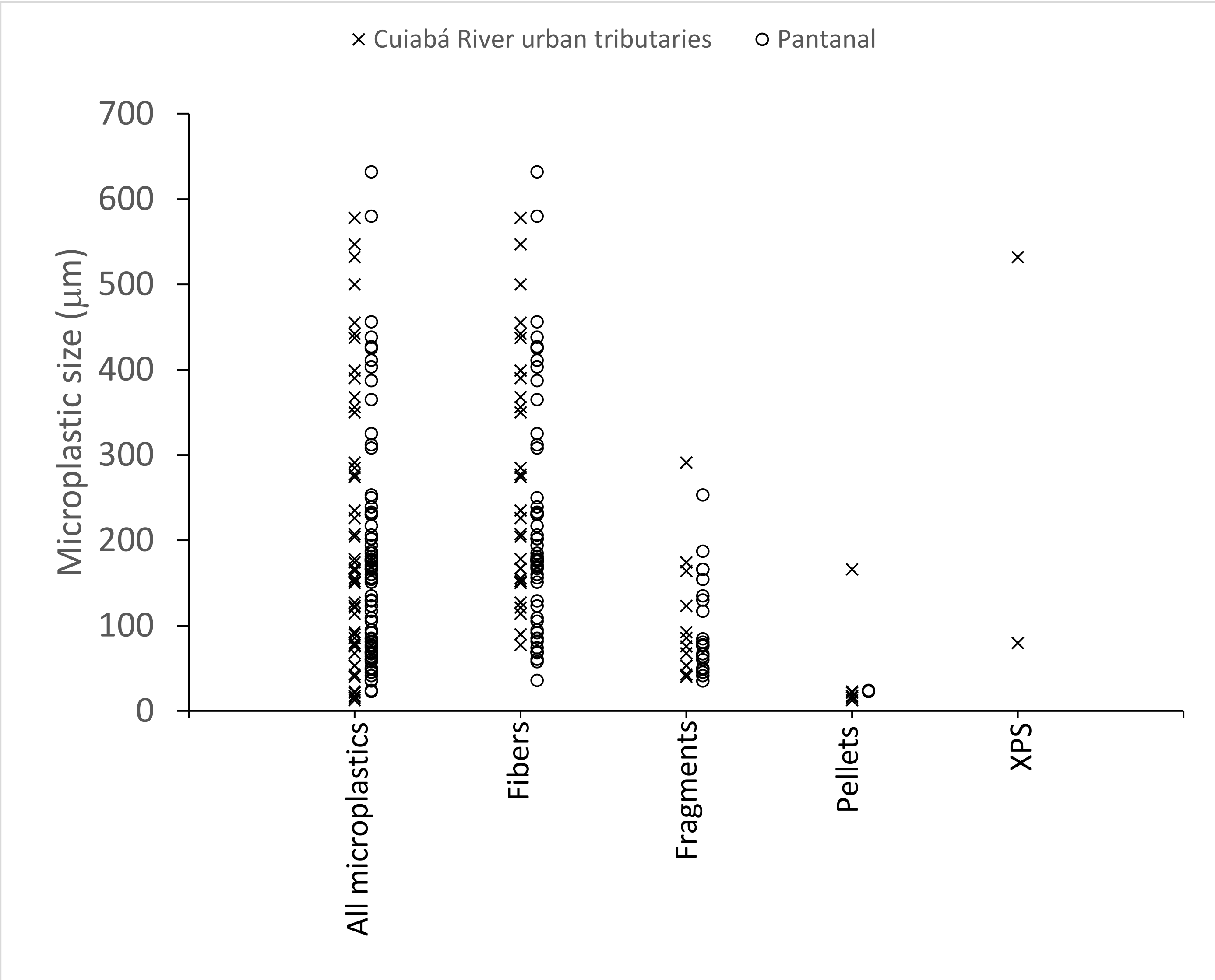

× Cuiabá River urban tributaries
○ Pantanal
Microplastic size (µm)
700
600
500
400
300
200
100
0
All microplastics
Fibers
Fragments
Pellets
XPS

Table 1(on next page)

Sampling sites characteristics.

Table 1. Sampling sites characteristics.

Site	Name	Locality	Water Body	Date	Latitude	Longitude	Sampling Platform	Location and Characteristics	Current	Surroundings	N of samples
Upland urban tributaries	Lavrinha	Cuiabá	Lavrinha Brook	Mar-18	-15.65698	-56.06144	Wading	Close to mouth, channel 1 m wide, sand and gravel bottom	Fast	Suburban, residential	5
	São Gonçalo	Cuiabá	São Gonçalo Stream	Mar-18	-15.64580	-56.06671	Wading	Close to mouth, channel 3 m wide, sand and gravel bottom	Fast	Suburban, residential	5
Pantanal lowlands	Porto Cercado	Porto Cercado	Cuiabá River	Apr-18	-16.51563	-56.37671	Boat	Middle of the river, channel 140 m wide, sandy bottom, avg. discharge = 280 m^3s^{-1}	Turbulent	Rural, fishing, hotel	5
	Riozinho	Porto Cercado	Floodplain water column	Apr-18	-16.57231	-56.40889	Boat	Close to the inactive river channel, water depth 1 m	Slow	Natural, flooded riparian forest	5
	Jatobá	Porto Cercado	Floodplain water column	Apr-18	-16.49780	-56.28585	Boat	Water depth 40 cm	Slow	Natural, flooded field	5
	Moquem	Porto Cercado	Floodplain pond	Apr-18	-16.55174	-56.37600	Boat	On the margin of a flooded abandoned channel, water depth 2 m	Slow	Natural, flooded pond margin	5