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ANALYSIS OF THE POTENTIAL PRESENCE OF MICROPLASTICS IN RIVER AND POTABLE WATERS IN ITUMBIARA, GOIÁS AND IMPACT ON WATER SECURITY

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ABSTRACT

The use of plastic materials is widespread worldwide. However, due to their low biodegradability, these materials have become a significant source of environmental pollution. The large-scale production of plastics, which began in the twentieth century, has not been accompanied by effective disposal practices, aggravating the problem in a scenario of accelerated population growth - from 1 billion to more than 8 billion people between 1900 and 2022 - and increased life expectancy. This growing consumption, combined with the persistence of plastics in the environment, has intensified human exposure to microplastics (PMs) and nanoplastics (NPs). PMs and NPs are mainly generated by the degradation of larger plastics, such as bags, bottles, and fishing nets; in addition to the wear and tear of everyday products, such as packaging, furniture, toys, synthetic clothing and personal hygiene items. These fragments pose risks to human and environmental health, either by accidental ingestion by animals - with accumulation along the food chain - or by direct exposure, such as in contact with synthetic materials, cosmetics or by ingestion of contaminated water. PMs/NPs have already been identified in human blood, lungs, and feces, associated with changes in the microbiota, inflammatory processes, and the release of chemical substances with endocrine disruptor potential, related to the emergence of metabolic, neurodegenerative, and cancer diseases. The objective of this study was to investigate the potential presence of PMs in the water of Itumbiara (GO). Samples of drinking water and the Paranaíba River were collected in areas close to the urban perimeter, analyzed by optical microscopy and recorded by means of photographs. No PMs were identified in the filtered water or tap samples. However, fragments of PMs were detected in effluent water samples and in the drinking fountain of an institution. In the effluent samples, bacteria adhered to the PMs were also observed. The results indicate the presence of PMs in the untreated water of the municipality, which represents a potential risk to human health, especially when this water is used for plant irrigation and animal consumption.

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INTRODUCTION

The history of plastic began in 1907, when Belgian chemist Leo Hendrik Baekeland invented bakelite, the first synthetic plastic, which stood out for its strength and durability. Thus, it quickly found applications in phones, utensils and other products. During World War II, the production of plastics expanded significantly to replace scarce materials, laying the foundation for the widespread use we see today. After the war, demand continued to grow as more applications were discovered, ranging from consumer goods to industrial, agricultural, and medical uses (MARCOLIN, 2006). Today, however, our dependence on cheap, quickly disposable, and extremely long-lasting plastic products has generated a very serious environmental problem (JONES, 2019; PLASTICS EUROPE, 2021).

The destination of plastic waste (among other types of waste), whose production exceeds 300 million tons annually, has led to a growing global concern. Inevitably, improperly discarded and unrecycled plastics end up reaching the riverbeds and ultimately the oceans, where they remain for centuries. Its degradation is slow, due to chemical properties, leading to several consequences: plastics can be broken down into microplastics (MP) and nanoplastics (NP), which in turn can be mistaken for birds, fish and other animals as food. Then, bioaccumulation occurs along the food chain, bringing risks to human, animal and plant health, thus impacting water security (AMATO-LOURENÇO *et al.*, 2021; LESLIE *et al.*, 2022; PERSIANI *et al.*, 2023). According to the National Water and Basic Sanitation Agency (ANA) and the United Nations (UN), Water Security exists when there is availability of water in sufficient quantity and quality to meet human, economic and environmental needs, accompanied by an acceptable level of risk related to droughts and floods. It is a fundamental concept for sustainable development (BRASIL, 2023).

Proof of this bioaccumulation is that PMs have already been found in samples of blood, intestine, liver, lungs, brain, placenta, semen, testicles, prostate, prostate tumor, atheromatous plaques (atherosclerosis) and feces of humans. But other sources have also been suggested, such as inhalation, skin contact and water contamination by microfibers released after washing synthetic clothes in machines, among other sources. Among the factors that generate MPs are the decomposition of larger objects, such as bags, bottles, and fishing nets; drainage of pipes; leakage from production facilities; friction of tires with the asphalt; washing clothes; irregular garbage disposal; use of acrylic or latex paints; use of cosmetics; and "glitters". Among the factors that generate NPs, we can mention the degradation of everyday products, such as packaging, furniture, bags, toys, and personal

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hygiene products; degradation by UV radiation; and fragmentation of plastics due to mechanical action, hydrolysis and microbial activity (ALI *et al.*, 2025; JONES, 2019; LV *et al.*, 2024; MÜNZEL *et al.*, 2025; YUAN; NAG; CUMMINS, 2022).

Once inside the body, PMs/NPs interact with the immune system, alter the microbiota, and induce inflammation. This alteration of the intestinal microbiota, called dysbiosis, is an alteration in the composition and function of the bacteria that inhabit the gastrointestinal tract. The inflammation that follows results in, among other characteristics, an increase in intestinal permeability, allowing the passage of chemical substances from these microorganisms and from food – including PMs/NPs – into the bloodstream. The main health risk involves the possibility of release, after exposure to PMs, of bisphenols and phthalates, known endocrine disruptors (EDs). These compounds are associated as risk factors for metabolic, neurodegenerative, reproductive, cardiovascular diseases and even neoplasms (ALI *et al.*, 2025; BARCELÓ; CHEN *et al.*, 2025; PICÓ; ALFARHAN, 2023; BONI *et al.*, 2020; DENG *et al.*, 2024; IRFAN et al., 2025; JIMÉNEZ-ARROYO *et al.*, 2022; MÜNZEL *et al.*, 2025; ZHANG *et al.*, 2023; ZHAO *et al.*, 2023).

OBJECTIVE

The objective of this study was to evaluate the potential presence of PMs in water samples collected in the Paranaíba River basin, in the urban and rural areas of Itumbiara, as well as drinking water samples (tap, filter, water purifier, drinking fountain) from volunteers.

METHODOLOGY

The methodology used was based on the studies carried out by LESLIE *et al.* (2022) and JIMÉNEZ-ARROYO *et al.* (2022), adapted for analysis in water samples. It was not necessary to submit to the Research Ethics Committee (REC), as human samples were not used. The method of LESLIE *et al.* (2022) has been validated for human blood samples. Since human blood has more than 75% water in its composition, and it has already been shown that water from oceans and lakes has a similar composition, above 80% water (including marine animals and plants), we hypothesized similar results.

Imaging of the particles under an optical microscope (M.O.) provided information on particle size. A complete characterization in terms of size, shape, chemical composition, surface load are parameters that can strengthen our understanding of risk assessment

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processes. The main concern in this work was with plastic particles that can be absorbed by membranes in the human body. The method operationally defined by LESLIE *et al.* (2022) targeted particles that could be retained in a filter with a pore size of 700nm, that is, particles greater than or equal to 700nm in dimension. However, we use filters from 0.35um to 0.45um (350 to 500 nm) available in the national market.

Samples of 1 liter per point were collected, with 2 points of the Paranaíba River in an urban area (1 near the discharge of effluent into the river; another near crystal clear water); 2 volunteer houses in different neighborhoods, 1 in the periphery, 1 in the city center. When collecting water samples, gloves should be used to avoid cross-contamination with PMs potentially present in cosmetics, moisturizers, etc. The same protocol should be followed when handling laboratory instruments, such as beakers and pipettes. Glass pipettes should be used so that there is no cross-contamination with the plastic of pipettes made with this material. You should tie your hair, not wear makeup, and do not wear plastic or synthetic clothing (plastic microfibers present in synthetic clothing can contaminate the samples). Contact with plastic components should be avoided from sampling to the entire analytical process (SCHYMANSKI *et al.*, 2021).

The collected water was bottled in glass material. In the laboratory, the bottles were rinsed externally, before proceeding with the analyses. The chemical substances were checked, the samples were filtered, the appropriate filter was chosen (for 350 to 700 nm) and initially, they were analyzed by the M. O. to identify the particles, quantifying them and separating them by size. While other methods are expected to reach technical readiness, which is expected to take years, one can already begin to build a database for human exposure to particulate matter based on mass concentration, analogous to the particulate matter-based database for particulate matter from air pollution (LESLIE *et al.*, 2022; SCHYMANSKI *et al.*, 2021).

Colon cancer histopathology slides were used as a control, available in the laboratory, and sterile empty slides with only coverslips, never used, without liquid material, as a way of calibrating the O.M. before proceeding to the observation of the water samples.

RESULTS AND DISCUSSION

Only the main results are reported here for the sake of space limit. The data are representative of 3 samples collected from each source.

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In figure 1, it is not possible to observe the PMs to the M.O. directly, from the samples collected from the river near the effluent outlet, at the lowest increase (4x). However, it is possible to observe some points that resemble bacteria, and that are more visible when zooming in or when using the 10x magnification (figure 2). In addition, PMs also begin to become more apparent when zooming in, suggesting the association of PMs with bacteria (similar to what was described by Sierra *et al.*, 2020).

Figure 1: Sample collected from river (4x magnification) near sewage outlet

Figure 2: Sample collected from river (magnification 10x) near sewage outlet

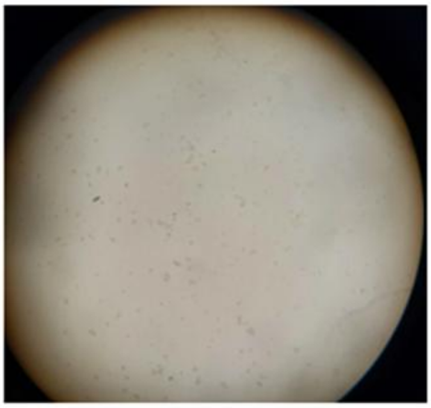


Figure 3: Sample collected from the tap in the center (magnification 10x) (drinking water)

Figure 4: Sample collected from a tap in the suburbs (4x magnification) sewage

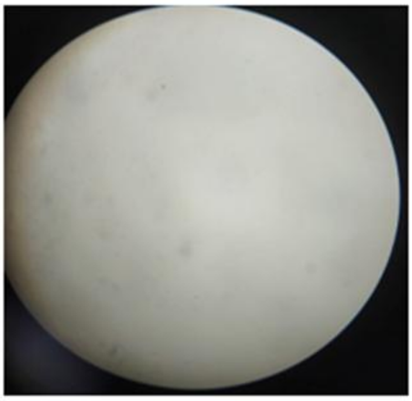
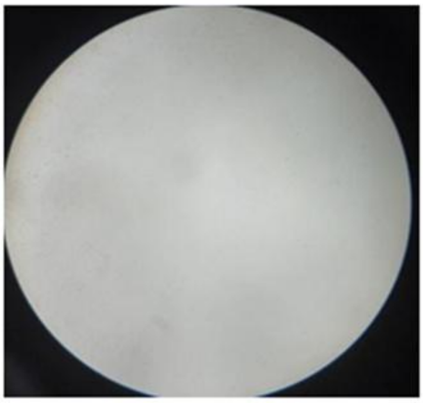


Figure 5: Sample collected from a drinking fountain in a peripheral institution (4x magnification)

Figure 6: Sample collected from a residential purifying filter on the outskirts (10x) (4x magnification) near the exit



The "typical" appearance of PM is clearer at the larger magnification (40x), figure 7, where an image with polygonal morphology is demonstrated, similar to that found in other articles (D'HONT *et al.*, 2021; VÁSQUEZ-MOLANO; MOLINA, DUQUE, 2021).

We suggest that the cells with bacterial characteristics seen in the sewage water samples are *Escherichia coli bacilli* or others, also of intestinal origin, such as *Firmicutes* and *Bacteroides* sp.

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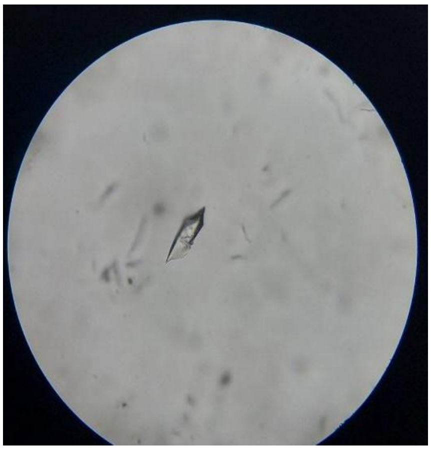
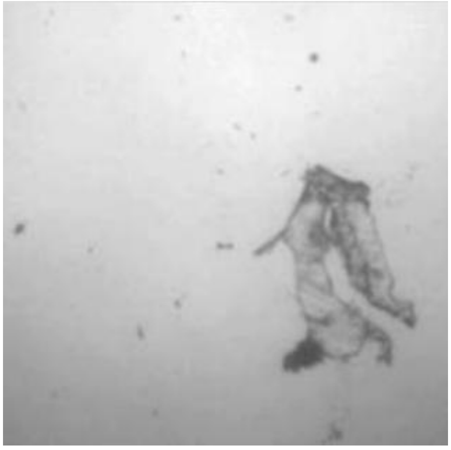
Figure 7: Sample collected from a drinking fountain of an institution in the periphery (40x magnification) near the sewage outlet



Source Figures 1 to 7: authorship

Figure 8: Plastic fragment (40x)



Source: figure 8: VÁSQUEZ-MOLANO; MOLINA, DUQUE, 2021

Soon, we intend to analyze other river samples near regions where sewage is released into the rivers, to identify and confirm some of these and other bacteria through molecular techniques. Our hypothesis is that many of the PMs found would also be of human intestinal origin, and eliminated in the feces, which has also been confirmed by other authors (KE *et al.*, 2023), however, not in the region and vicinity of the State of Goiás. It is not clear, however, whether this association occurs already *in vivo* or by accumulating for a long time in the waters of rivers, allowing their proliferation outside the human body.

In China, Zhang *et al.* (2023) noted that PM-associated bacteria had strong potential drug resistance functions and could cause risks to ecosystems and human health. On the other hand, the results of Perveen *et al.* (2023), obtained in Madrid, Spain, indicated the dominance of *Pseudomonas*, *Aeromonas,* and *Bacillus* among antibiotic-resistant bacteria (ARBs) isolated from wastewater from sewage treatment plants. In addition, they also detected antibiotic resistance genes (ARGs) in the biofilm of PMs obtained from tap water (PERVEEN *et al.*, 2023).

In Figures 3, 4 and 6, we did not observe the presence of particles similar to PMs/NPs or bacteria, attesting to the quality of the treated water collected from the tap and purifying filter in the center and periphery, except from the drinking fountain of an institution in the periphery (Figures 5 and 7).

In this context, Freitas *et al*. (2017) have already carried out a study in Goiás on the quality of water in school drinking fountains, and found not only *Salmonella* and other coliforms, but also plasmids related to antibiotic resistance genes, however, they did not evaluate the presence of PMs.

FINAL CONSIDERATIONS

The presence of PMs was detected in samples of drinking and river water in the municipality of Itumbiara, Goiás. It is possible to have variations and contaminations unrelated to the water treatment, carried out by the basic sanitation company, so more drinking water analyzes must still be carried out, in order to reach a considerable and robust sample size.

It is not possible to analyze, in the short term, the samples from all houses and commercial establishments and public institutions in the municipality. However, in view of the above, it is possible to postulate that the treatment of river water in Itumbiara, which was rich in PM and bacteria at the time of dumping of waste into the sewage, is efficient, as it is found that there is minimal (public drinking fountains) or no presence (taps, residential purifying filters) of PMs and microorganisms (bacteria). The data suggest, therefore, that the PMs detected may have a mostly intestinal origin and, therefore, come from food. The results obtained will allow an approach of extension projects with the population, to prevent the improper disposal of garbage, especially plastic, while promoting environmental education strategies to reduce consumption, reuse and recycle plastic (and other materials), in addition to measures to mitigate the impact of metabolic diseases, neurological, cardiovascular, cancer and others, in the long term, caused by the release and presence of toxic substances in the air and aquatic environment to which the human, plant and animal populations are constantly exposed.

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