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Microplastics Ingestion by Copepods in Two Contrasting Seasons: A Case Study from the Terminos Lagoon, Southern Gulf of Mexico

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Abstract: This study evaluated the ingestion of microplastics (MP) by copepods in Terminos Lagoon (TL), a RAMSAR-listed site in the southern Gulf of Mexico. The evaluation was carried out in two contrasting seasons of 2022, as follows: the dry (April) and the rainy (October). Copepods were collected using a conical plankton net (mesh size of 200 µm). In the laboratory, a pool of all pelagic adult copepod taxa was picked, and the MP inside the organisms were extracted, classified, and photographed using traditional optical and scanning electron microscopy. A total of 268 MP particles were extracted from the interior of copepods; among them, 149 and 119 corresponded to the dry and rainy seasons, respectively. The ingestion rate in the dry season was 0.14, while in the rainy season, it was 0.11. In addition, fibers, plastic fragments, and microspheres with different colors (blue, red, black, green, transparent, and multicolored), sizes, forms (angular, round, triangular, and twisted), and textures were also detected. Fibers were the most abundant MP found in a proportion of more than 85%. In addition, in some sampling sites, microspheres were observed with high relative abundance values (80%). In some sites, fragments reach 20% of the total abundance. Significant differences were observed between the two seasons. The sites closest to the urban area adjacent to TL observed high diversity and abundance of MP. The higher abundance of MP in the dry season is due to lower river discharge, on the other hand. Thus, MP particles accumulate and become available for consumption by copepods. This is the first study that has revealed that the MP was ingested by the copepods in TL. Furthermore, this study provides a baseline information for future research on the abundance of MP in the Gulf of Mexico region.

Keywords: plastic pollution; microplastics; copepods; seasonal variability; Terminos Lagoon; Gulf of Mexico

1. Introduction

Plastic pollution in coastal and oceanic environments has been recognized as the most serious environmental problem affecting marine life [1] and threatening human health [2]. From their origin to their disposal and transportation through the water bodies, plastics are subjected to chemical, mechanical, and biological degradations until they become converted into small particles (~5 mm in diameter) known as microplastics (MP) [3]; nonetheless, MP are also deliberately manufactured as microspheres for application in cosmetic products and in the textile sector [4]. However, independently of their nature, MP are transported
through rivers and streams until they reach the coastal zone [5,6], where they are present in miscellaneous forms, including fibers, granules, microspheres, and fragments that vary in size, density, and color [7,8]. MP have become a serious environmental problem because, due to their small size, they look like the natural food of some species and, therefore, they can be easily ingested by a wide range of marine organisms, including those filter-feeding species of the zooplankton, such as copepods [9], whose diet is highly diverse, including phytoplankton, bacteria, detritus, and even other copepods [10].

Copepods are the most abundant crustaceans in the marine environment, playing a key role in the ecosystem due to their position in the food web as primary consumers [11]. Since these organisms can feed indiscriminately on the suspended particles [12], the probability of MP ingestion is very high [13]. Indeed, some studies have indicated that MP ingestion by copepods is significant, and their exposure negatively affects important aspects of the life cycle of these organisms, such as growth, reproduction, and fecundity [14,15].

Numerous studies have documented the ingestion of MP by copepods in coastal and oceanic environments worldwide. For example, in the Atlantic Ocean, it has been reported that copepods can ingest polystyrene particles up to 1 mm in diameter and that plastic particles can easily adhere to different parts of their body with strong repercussions on the vital functions of the organisms [16]. In the English Channel (United Kingdom), it has been documented that the dominant copepods in the region selectively ingest MP (fibers or microspheres), indicating that the shape and size of the MP are important factors to consider [17]. In the Mediterranean Sea, Costa et al. [18] documented that the ingestion of MP by copepods not only negatively influences their life cycle but also has strong implications for the organisms that feed on them (i.e., jellyfish) since a transfer of MP through the food web can occur (bioaccumulation), which represents a serious threat to a high diversity of organisms, including humans. In addition, it has been documented that the ingestion of MP by copepods has strong effects on the mobility (swimming) speed of organisms, reducing it by up to 40%, which affects the escape/feeding strategies, negatively disturbing the transfer of carbon and energy through the pelagic food web [19]. In the Jiaozhou Bay (Yellow Sea), Zheng et al. [20] analyzed the abundance, shape, size, and chemical composition of the MP ingested by copepods across four seasons, showing that the ingestion was significantly higher in winter and spring than in summer, possibly related with the seawater temperature variability.

There are few studies in Mexican waters on the ingestion of MP by copepods. Recently, the in situ MP ingestion by five taxonomic groups of zooplankton (including copepods) of the central Mexican Pacific during two climatic seasons (rainy and dry) was addressed by Zavala-Alarcón [21], who showed that copepods presented the highest rate of ingestion with fragments as the most conspicuous material; the authors concluded that there were no significant differences in MP ingestion between the two seasons analyzed.

While studies on the ingestion of MP by copepods have begun to gain relevance worldwide, research on this topic in Mexico still needs to be fully addressed, so studies that qualitatively and quantitatively assess the ingestion of MP by copepods have become imperative. The presence of MP in coastal regions can reach at least 14.9 trillion particles weighing more than 93,000 tons [22], considering that coastal regions are the impacted sites, because they host a high diversity of organisms that could potentially consume MP.

The Terminos Lagoon (TL) in the coastal region of the southern Gulf of Mexico is important because of its large size and high species richness. Due to an exchange of seawater from the Gulf of Mexico and the contribution of freshwater through three larger rivers that flow into its interior, TL is a key site for the spawning, growth, and reproduction of numerous species with high ecological and commercial values [23]. TL is surrounded by abundant mangrove forest vegetation, representing a habitat for numerous bird species [24]. TL was declared in 1994 as a protected natural area by the Mexican state because it is a vital site for conserving ecological diversity. In 2004, it was listed among the RAMSAR sites in the world.
It is recognized that TL is threatened by population growth and the nearby oil industries generating contaminants that flow into the lagoon. For example, recent studies have documented a high diversity of contaminants in its interior, including polycyclic aromatic hydrocarbons [25], organochlorine pesticides [26], potentially toxic elements (e.g., As, Cd, Cr, Cu, Ni, Pb, V, and Zn) [27], and MP [28].

Studies on the impact of MP on the species living inside TL have begun to gain importance in recent years, and a few studies have addressed the fact that MP strongly affects the populations of oysters [28] and blue crabs [29]. However, the impact of the MP on the species positioned at the lowest trophic levels of the food web, such as zooplankton, in particular, copepods, remains unexplored.

This study aims to assess the ingestion of MP by microcrustaceans (Copepods) in TL concerning two contrasting seasons of 2022, dry and rainy. The main research questions postulated for this research were (1) What type of MP is most ingested by copepods in TL? and (2) Is there any variability in the ingestion of MP by copepods between the dry and the rainy seasons? To fulfill this aim, we implemented a sampling strategy that includes capturing copepods in the maximum drought (April) and maximum rainy seasons (October). The copepods were captured in eleven sites that covered the entire coastal lagoon, including its connection with the open waters of the Gulf of Mexico and the three larger rivers that flow into it. This topic has remained unexplored in TL; hence, this study will increase the knowledge of the threats to organisms living in the TL. In addition, this study will provide baseline information for future research on the abundance of copepods in the TL.

2. Materials and Methods

2.1. Study Area

Terminos Lagoon is located in the southern Gulf of Mexico, in the western portion of the Yucatan Peninsula, in the Campeche State of Mexico. With a total area of more than 1500 km², the site is considered one of the largest coastal lagoons in the Mexican territory [30] (Figure 1). The lagoon is separated from the open waters of the Gulf of Mexico by Del Carmen Island, communicated to the sea through the following two mouths: Puerto Real (PR) to the east and Del Carmen (DC) to the west. The coastal lagoon is a highly dynamic environment due to different physical aspects, including tides and winds, and the rivers discharge from three large rivers located in its southern portion, i.e., Palizada, Chumpan, and Candelaria (Figure 1). The exchange between the lagoon and the Gulf of Mexico is manifested by the inflow of seawater from the PR inlet. In contrast, water outflow from the lagoon to the gulf occurs through the DC inlet [31,32]. In climatic terms, the following three contrasting seasons characterize the region: (1) the dry season, which occurs from March to April; (2) the rainy season from early May to October; and (3) the “Nortes” season, which occurs from November to February, in which strong (up to 100 km/h) and persistent northerly winds from the north impact the region, generating changes in the hydrographic properties of the water column [32]. In biological terms, the coastal lagoon is recognized for its high biological diversity, with abundant mangrove forest vegetation that serves as a refuge and feeding area for different emblematic species. Hence, the Mexican authorities consider the region a natural sanctuary, with the Flora and Fauna Protection Area category, and it is internationally recognized as a RAMSAR site [33].
2.2. Sampling

Two systematic sampling expeditions were carried out in TL in two contrasting seasons of 2022. The first was carried out between April 25 and 28 (the month of maximum drought), and the second was carried out between October 3 and 7 (the month of maximum rain). Sampling was carried out with an outboard boat. In both expeditions, zooplankton was collected with a conical plankton net (nylon material, 50 cm in mouth diameter, 150 cm long, 200 µm mesh size) configured with a mechanical flowmeter (General Oceanics 2030R) by horizontal hauls of the subsurface stratum. Zooplankton was collected in eleven sites that covered the entire coastal lagoon, including its connection with the open waters of the Gulf of Mexico and the connection of the three larger rivers that flow into it (i.e., Palizada, Chumpan, and Candelaria) (Figure 1). The time of each haul was 10 min at a speed of ~2 kt. The organisms collected were immediately fixed onboard, firstly with a solution of 4% formalin added with sodium borate for 24 h in air-tight glass jars, then transferred to a 70% ethanol solution for final preservation.

2.3. Laboratory Analyses

The samples were processed in the laboratory immediately after collection. From the original samples collected in each site, adult copepods were removed using stainless steel micro dissecting needles and glass Petri dishes under a Carl Zeiss Stemi 508 stereo microscope equipped with a Zeiss Axiocam 105 color. During this stage, a deep visual inspection of the organisms was carried out to identify the possible adhesion of MP throughout the...
body (cephalothorax, appendages, telson, antennae, etc.) by removing all external particles. The separated organisms were carefully rinsed with distilled water and placed in 10 mL glass vials in groups of 1000 copepods for each sampling site (Figure 2).

![Figure 2. Laboratory work steps (refer to Materials and Methods section for details). (a) Original zooplankton samples, (b) copepod’s separation from the original samples, and (c) adult copepod selection.](image)

To identify the MP ingested by copepods, we applied the technique proposed by Desforges et al. [34]. This technique consists, basically, of the complete dissolution of the organisms through concentrated nitric acid (HNO₃), considering that all organic material (tissue, intestine, appendages, telson, antennae, etc.) is completely diluted, releasing the plastic particles lodged inside each organism. We applied this technique by adding 5 mL of concentrated HNO₃ to each vial, which was then heated in a water bath (Cole-Parmer Polystat) at a constant temperature of 80 °C for 25 min. After that time, the acid was filtered through glass fiber membranes (Whatman GF/F) to retain the MP contained in each sample. HNO₃ has been used in several works to extract plastic particles from zooplankton and other biotas because it completely digests tissue and exoskeletons, thus reducing interferences [35]. However, there are still controversies on the use of this technique because the use of acid at high temperatures can dissolve some and therefore underestimate the number of MP [36,37]; for example, recent research suggests that polyoxymethylene, polyurethane, polyisoprene, nitrile rubber, and polymethyl methacrylate had ≥90% mass loss in nitric acid [35]. Nonetheless, the use of HNO₃ to extract MP from the interior of organisms has been successfully applied and is still in use due to the efficient digestion of biota [21,38,39].

The MP retained in each membrane were then counted, classified, and photographed using optical microscopy and scanning electron microscopy techniques to identify the type, color, shape, size, and surface features, as described in Flores-Cortés and Armstrong-Altrin [40] and Flores-Ocampo and Armstrong-Altrin [41]. It is important to note that during all stages of the laboratory analyses, precautions were considered to avoid the contamination of samples by external MP items, including using material made of glass and/or stainless steel and cotton caps, clothing, and gowns. Finally, the ingestion rate was calculated following Zavala-Alarcón et al. [21]

The congruence between the similarity matrices for the MP composition from the two datasets was evaluated using the Mantel test. By permuting each element in a calculated matrix of dissimilarity indices, this test derives a distribution of correlation values by evaluating the goodness-of-fit between two multivariate datasets [42–45]. The resulting R-statistic resembles Pearson’s correlation coefficient (r); the Mantel R-statistic will approach 1 as dissimilarity matrices get closer to one [46].
3. Results

Dissolving the copepods from TL allowed us to identify and classify MP of different textures, shapes, sizes, and colors, including fibers, plastic fragments, and microspheres. Two hundred and sixty-eight MP items were extracted from the copepods’ interior; 149 were extracted during the dry season, and 119 were extracted during the rainy season. The miscellaneous material and their relative abundance are summarized in Table S1 (Supplementary Materials).

Fibers are the most conspicuous material in all sites and are of different sizes, flexibilities, brightness, and colors, including blue, transparent, red, orange, and yellow (Figure 3a–i). Blue is the first dominant, and transparent is the second dominant color. Among MP, fragments are abundant at all sampling sites and vary in their sizes, shapes (rounded, angular, and triangular), and colors (red, blue, green, multicolored, and transparent) (Figure 3j–n). Other MP, such as microspheres of different sizes and colors, like green, black, and transparent, are also observed (Figure 3o–r).

Figure 3. Cont.
Figure 3. Miscellaneous MP ingested by copepods from Terminos Lagoon evaluated in two contrasting seasons of 2022, dry and rainy seasons, (a–i) fibers with different colors (red, blue, black, and transparent), brightness, sizes, and flexibilities. (j–n) Fragments of MP with different colors (red, green, multicolored, and transparent), sizes, and shapes (angular, rounded, and oval), (o–r) microspheres (pellets) with different sizes and colors (green, black, and transparent). The black arrows pointed out the MP items.

Figure 4 shows the types of MP (fibers and microspheres), with different textures and shapes. The fibers (Figure 4a–h) showed a different degree of roundness and twisting, which may indicate the state of conservation when the copepods ingested them. The photomicrographs also showed adhering particles (possibly MP; Figure 4b,c) and crystal overgrowth on the fibers (Figure 4d). MP pellet (microsphere; Figure 4i) types are also detected.

Regarding their relative abundance, the MP displayed interesting variations between both sampling seasons of this study. During the dry season, blue fibers were the most conspicuous material identified in all sampling sites (58%), followed by transparent, red, black, multicolor, and green fibers, which reached 38%, 33%, 25%, 22%, and 8% of the total MP, respectively. Transparent microspheres (pellets) reached a relative abundance of 17%; MP fragments with different colors (red, blue, green) reached 15% of the total abundance; and films reached 8% of the total abundance in some sampling sites.
MP relative abundance differs in each sampling station and season. For example, during the dry season, the MP diversity is higher in the rainy season (see Table S1 in Supplementary Materials). In terms of their horizontal distribution, except for station P1, which is closest to the Palizada River (see Figure 1), all sites showed a wide diversity of MP, particularly in stations P3 (number of MP n = 9/1000 copepods, an ingestion rate of 0.009), CH3 (n = 7/1000 copepods, an ingestion rate of 0.007), and DC (n = 4/1000 copepods, an ingestion rate of 0.004), which are located near the Ciudad del Carmen (Figure 5).

During the rainy season, MP diversity and relative abundance differ from those observed during the dry season. In this case, transparent and blue fibers were the most abundant MP item (33/1000 copepods, an ingestion rate of 0.03), followed by black and red fibers, with nine and five items, respectively. In the rainy season, no green or multicolor fibers are documented. In terms of their relative abundance in each sampling site, the results showed a lower diversity of MP relative to the dry season. For example, at station P3, only five types of MP were documented. In comparison, at stations C2 and C3, only three types of MP were observed (Figure 5). However, diversity and abundance are lower than in the dry season. High MP values are observed at stations P3, CH3, and DC, located closer to the urban area of the Ciudad del Carmen (see Figure 1).
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Figure 5. (a) Microplastic items ingested by copepods from the Terminos Lagoon in each sampling site during the dry season (April 2022); (b) microplastic items ingested by copepods from Terminos Lagoon in each sampling site during the rainy season (October 2022).
Finally, the Mantel test performed between distance matrices showed no correlation between the two contrasting seasons. Concerning MP composition, Mantel’s $r$ is 0.34 ($p = 0.05$), while Mantel’s coefficient is 0.05 ($p < 0.05$). These results show that MP composition significantly differed between the two contrasting seasons.

4. Discussion

Both the field and laboratory techniques applied in this study allowed us to identify the MP ingestion by the TL copepods. MP of different shapes, sizes, textures, and colors, including fibers, fragments, and microspheres, were identified. MP were higher in the dry season and in the sites closest to the urban area of Ciudad del Carmen.

Copepods are scan-feeding current organisms, generating a feeding current within their mouth, and when potential prey enter the stream, they either trap or reject the particles suspended in the water column [47], including MP. There are studies addressed that MP ingestion by copepods is high, which has been well-documented in contrasting environments around the world, including the Atlantic Ocean [16], the English Channel, the United Kingdom [17], the Mediterranean Sea [18], the Baltic Sea [48], and the Arctic environment (Greenland) [49]. In these, a wide variety of MP ingested by copepods have been documented, including fibers, pellets, and fragments with different colors, shapes, and sizes, which are similar to the results of this study and in agreement with our results.

Our results showed that the MP ingested by the copepods from the TL presented different colors and brightness, which could indicate their age or living time in the environment and their origin. Indeed, while items with a more intense color reflect pristine MP, the uncolored or transparent materials are more aged MP [50]. It has been documented that copepods tend to ingest both aged and pristine MP [14].

Although we do not have measurements to identify the chemical composition of the MP ingested by the copepods, some authors indicate that the color of each MP can provide clues on this. For example, while transparent MP are associated with containers, wraps, and bags [40], blue MP are associated with fishing gear [41], and black and green MP can be originated by washing synthetic clothing [51]. The wide variety of MP colors in our study suggests that the main source may be related to the urban area of the Ciudad del Carmen that discharges material into the lagoon, including wastewater from washing clothes. Another aspect to consider is the possible contribution of MP derived from the fishing activities in the southern Gulf of Mexico, which could reach the interior of the coastal lagoon through the connection with the sea. Regarding toxicity for copepods, it is currently known that polyethylene and polystyrene microbeads are highly harmful compounds, particularly for species such as *Acartia tonsa* Dana 1849–1852 and *Calanus finmarchicus* (Gunnerus, 1770) [9].

Yet another important aspect to consider is the chemical composition of the MP, which is potentially toxic to the environment and, therefore, to copepods. It is known that MP can release significant concentrations of toxic chemical components that strongly affect different stages of the lifecycle of copepods. Indeed, it has been documented that the chemical composition of MP had a toxic effect on feeding, fecundity, and survival, inducing changes in the body size of some species [52]. Additionally, it has been documented that polystyrene microbeads decrease the fecundity rates in some species of copepods [53].

In our study, the maximum abundance of MP found during the dry season could be explained by: (1) During these months, there is a reduction in the discharge of water and sediments by the rivers into the lagoon; therefore, there is an absence of continuous circulation and water exchange. This condition was previously documented particularly for the Palizada River by Fichez et al. [54], who showed a monthly flow rate of $<70 \text{ m}^3\text{s}^{-1}$ between March and April (their Figure 2), while during the rainy season, the flow of the river can exceed $288 \text{ m}^3\text{s}^{-1}$ [55]. Hence, during the dry season, the particles tend to accumulate and thus become available for consumption by living organisms in the lagoon; (2): However, the “Nortes” season ends in February; during the following months (mainly March and April), it is common the presence of intense winds, which can then transport...
MP (either by air or by currents) and/or induce the mixing of the water column, so this dynamic can generate greater availability of MP for consumption by copepods. Evidence of this mechanism was presented in the Colombian central Caribbean waters, where wind intensification has been related to a greater abundance of MP in the water column [56]. The high abundance of MP in the sites near Ciudad del Carmen can be explained by the high accumulation of domestic waste derived from that city (see Figure 1), a locality with increasing population growth whose number of inhabitants exceeds 190,000 [57].

Recent research suggests that the ingestion of MP by copepods is significantly higher in winter and spring than in other seasons, which is associated with changes in seawater temperature [20]. In our study, the highest number of MP was found in April, which could reflect an effect of the temperature on the MP ingestion because, during this month, the water temperature in TL is considerably lower than that in October [58]. Nonetheless, in recent research, no significant differences were found in MP ingestion by copepods due to seasonality [21]. In terms of the ingestion rate by copepods, our study displayed values of 0.14 and 0.11 for the dry season and the rainy season, respectively, which are higher than those previously reported in the central Mexican Pacific, where the ingestion rate by the copepods of the region has been calculated as 0.02 [21]. The results of this study reveal that the copepods from TL are more exposed to plastic MP pollution due to the proximity of Ciudad del Carmen, as mentioned above.

In Mexico, studies on the ingestion of MP by aquatic organisms have gained attention in recent years, and now it is well-known that MP can be consumed, bioaccumulated, and transferred from zooplankton (e.g., cladocerans) to organisms at higher trophic levels, including amphibians [59]. However, studies of MP ingestion by organisms constituting the zooplankton, particularly copepods, are still lacking. This becomes more relevant when considering the trophic position in which copepods are located. For example, being a primary consumer, these organisms represent food for numerous species. Therefore, the MP ingested by these organisms can be transferred along the food web, reaching even top predators. In this sense, some studies for Mexican waters have documented the presence of MP in the digestive tracts of fishes [60] and pinnipeds of the Gulf of California [61], which shows evidence of trophic transfer occurring along the food web, which can impact human populations (bioaccumulation).

5. Conclusions

The results of this study show, for the first time, evidence of MP ingestion by copepods from the TL, a coastal environment recognized for its high biological diversity, included in the list of RAMSAR sites worldwide. MP particles are conspicuous material observed in all sampling sites in both climatic seasons, which include fibers (the most abundant material), fragments, and pellets with different sizes, colors, and shapes, providing evidence about their possible origin. The highest abundance and variety of MP are observed at the site close to the urban area of Ciudad del Carmen, which is attributable to waste generated by the city. Relative to the rainy season, the dry season is higher in the abundance of MP, which can be explained by the variation in the amount of water discharge into the TL and the effect on climatic changes due to the “Nortes” season. The results of this study represent a baseline condition that motivates future research to understand the effects of MP ingestion on organisms positioned at the lowest levels of the food web, like the copepods. More field observations and experimental studies in the laboratory are needed, seeking a more complete vision of the impact of MP ingestion by copepods that we documented here and thus be able to present a clearer picture of this serious environmental problem.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/microplastics3030025/s1: Table S1. Relative abundance (%) of the microplastics ingested by copepods from Terminos Lagoon in two contrasting seasons of 2022, the dry (April) and the rainy (October).

Funding: This study was primarily funded by the DGAPA-PAPIIT-UNAM project #IA200123 “Evaluación de la ingesta de microplásticos por microcrustáceos (Copepoda) en la Laguna de Términos, sur del Golfo de México”. Additional funding was provided by the Instituto de Ciencias del Mar y Limnología, UNAM (projects 144, 145, 627, and 628). CONACyT, México sponsored AMM through a graduate scholarship (CVU 1233459).

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The datasets generated during this study are available from the corresponding author on request.

Acknowledgments: The authors deeply appreciate the support provided by Alejandro Gómez Ponce, Andrés Reda Dearly, Hernán Álvarez Guillen, Carlos Mauricio Torres Martínez, Franco Antonio Rocha Díaz, Zayra López Cabello, José Gilberto Cardoso Mohedano, Rosela Pérez Ceballos, and Francisco Ponce Núñez. Sergio Castillo Sandóval provided technical support during the laboratory analyses. Laura Gómez Lizarraga provided technical support during the acquisition of electron microscope photographs. Helpful comments from three anonymous reviewers improved our presentation.

Conflicts of Interest: The authors declare no conflicts of interest.

References
8. Darshan, M.S.; Siddaraju, K.; Madesh, P. Textural characteristics and abundance of microplastics in the Nethravati river estuary sediments, south-west Mangalore beach, India. J. Indian Sediment. Assoc. 2023, 40, 29–42. [CrossRef]


39. Savino, I.; Campanale, C.; Trotti, P.; Massarelli, C.; Corriero, G.; Uricchio, V.F. Effects and Impacts of Different Oxidative Digestion Treatments on Virgin and Aged Microplastic Particles. *Polymers* 2022, 14, 1958. [CrossRef] [PubMed]


44. Fall, L.M.; Olszewski, T.D. Environmental disruptions influence taxonomic composition of benthic podacean communities in the Middle Permain Bell Canyon Formation (Delaware Basin, West Texas). *Palaios* 2010, 25, 247–259. [CrossRef]


59. Manríquez-Guzmán, D.L.; Chaparro-Herrera, D.J.; Ramirez-Garcia, P. Microplastics are transferred in a trophic web between zooplankton and the amphiobian Axolotl (Ambystoma mexicanum): Effects on their feeding behavior. *Food Webs* 2023, 37, e00316. [CrossRef]