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Description of microplastics on the coast of La Guancha in Ponce, Puerto Rico

Descripción de microplásticos en la costa de La Guancha en Ponce, Puerto Rico

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Abstract

La costa de La Guancha en Ponce, Puerto Rico, se localiza en una zona turística y zona portuaria. El propósito de esta investigación fue conocer y analizar qué tipo y qué cantidad de microplásticos se encuentran en esta área. Para la investigación de campo, se mide 200 metros a lo largo de la costa. Por cada 50 metros se escoge un cuadrante aleatoriamente, totalizando con 4 muestras de arena. Una vez seca la arena, se cierne y se identifican microplásticos. Las partículas de plástico encontradas se pesan en una balanza analítica y luego se colocan en bolsitas de muestras. Luego de muestrear la costa durante 5 meses, se clasificaron los microplásticos en categorías tales como fragmentos, pellets, fibras y filamentos. La categoría más abundante fueron los pellets, luego fragmentos, filamentos y por último fibras. Además, se realizó la prueba de *Kruskal-Wallis*, la cual reflejó que no existe diferencia significativa en la cantidad de micro plásticos en la playa de la Guancha de Ponce Puerto Rico y los cuadrantes de muestreo ($p > 0.05$). La realización de esta investigación es de utilidad, dado que los microplásticos plantean una de las amenazas más severas para la sostenibilidad de los hábitats sensibles, la vida silvestre, la ecología y los océanos.

Pellet, Fibra, Fragmentos

Resumen

Microplastics were first recorded in North America in marine plankton along the New England coast in the 1970s (Masura, 2015). Since then, they have been found in most large bodies of water such as oceans, seas, lakes, and rivers (Masura, 2015). This research aimed to describe which type and amount of microplastics are found on the coast of La Guancha a tourist and port area, in Ponce, Puerto Rico. 200 meters were measured along the coast for field research. A quadrant was selected randomly for each 50 meters. Plastic particles were found, weighed on an analytical balance and then placed in sachets. After sampling the coast for 5 months, microplastics were classified into categories such as fragments, pellets, fibers and filaments. The most abundant category were the pellets, followed by fragments, filaments and finally fibers. In addition, the Kruskal-Wallis test was carried out, which showed that there is no significant difference between the amount of microplastics in the coast of La Guancha in Ponce, Puerto Rico and the sampling quadrants ($p > 0.05$). Therefore, microplastics were described in all the quadrants during the research period. The research findings are useful, given that microplastics pose as one of the most severe threats to the sustainability of sensitive habitats, ecology and oceans.

Fragments, Pellets, Fibers And Filaments

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Introduction

Microplastics were first recorded in North America in marine plankton along the New England coast in the 1970s (Masura, 2015). Since then, they have been found in most large bodies of water such as oceans, seas, lakes, and rivers (Masura, 2015). The microplastics are located in cleaning products, hygiene either toothpaste and cosmetics such as exfoliants (Greenpeace Organization, 2016). According to Masura (2015), the fibers that come off synthetic clothing and rope are microplastics that also end up in bodies of water.

According to the Greenpeace Organization (2016), microplastics consist of a diameter of less than 5mm on any of its sides composed of polyethylene, polypropylene or polystyrene material; They also have the ability to attract chemicals and release them. The micro pearls, fibers and many of these microplastics are small enough to pass through wastewater treatment plants and enter a watershed (Masura, 2015). According to PhMj (2014) the coast of Guancha in Ponce, Puerto Rico is a beach where sand particles vary from 0.0625 mm to 2 mm in diameter. The coasts of Puerto Rico vary in three categories: rocky cliffs and promontories; mangrove coasts; and sandy or gravel beaches (PhMj, 2014).

The beach of La Guancha is a combination of mangrove coasts and sand or gravel, since it is located in a water transition zone (PhMj, 2014). The level of the sea is mostly low so the depth of the sea is estimated far from the coast.

Sabaté (2016), published the topic of plastic microspheres in hygiene products such as exfoliators or granular toothpaste that have a composition based on synthetic developments such as polypropylene (PP), polyethylene terephthalate (PET), and polymethyl methacrylate (PMMA). This author commented that these particles are capable of forming associations with pollutants such as pesticides (Sabaté, 2016).

The microplastics filter in the subsoil, then they are released in the sea, they pass to the fish and then to the human food (Sabaté, 2016). The organization Greenpeace (2016), published that 83% of Norwegian lobsters have microplastics in their stomach.

Galloway & Lewis have stated that oysters exposed to microplastics during gametogenesis lead to a reduction in their energy absorption and reproductive performance (Galloway & Lewis, 2016). However, Greenpeace (2016) pointed out the lack of data and lack of knowledge about the toxicity of micro plastics in humans. Likewise, it points out the potential of the surface of these particles to transport and disseminate pathogens that are relevant to diseases humanities (Greenpeace Scientific Department, 2016). Ogunola & Palanisami (2016), estimated that the world fishing fleet threw approximately 135,400 tons of plastic fishing tools and 23,600 tons of packaging materials into the ocean. The abandoned, lost or discarded fishing utensils is a source of plastic waste for the fishing and aquaculture sectors, but its contribution is little known at regional and global level.

The production of plastics has increased exponentially since the beginning of the 1950s, reaching 322 million tons in 2015 (Lusher, A.L., Hollman, P.C.H., Mendoza-Hill, J.J., 2017). This figure does not include synthetic fibers, which accounted for an additional 61 million tons in 2015 (Lusher, A.L., Hollman, P.C.H, Mendoza-Hill, J.J., 2017). It is expected that plastics production will continue to increase in the foreseeable future and it is likely that production levels will double by 2025 (Lusher, A.L.; Hollman, P.C.H .; Mendoza-Hill, J.J., 2017). It has even been estimated that in 2010 between 4.8 million and 12.7 million tons of plastic waste entered the oceans (Lusher, A.L., Hollman, P.C.H., Mendoza-Hill, J.J., 2017).

As a consequence, the human being is prone to the exposure of microplastics when consuming seafood or fish, since the animal carries those chemical properties in its digestive tract; as well as the chemical substances that are degraded by the high temperatures in cooking them. Therefore, this leads to this research to describe the micro plastics found in the coast of La Guancha in Ponce, Puerto Rico.

Marine debris such as microplastics poses one of the most severe threats to the sustainability of sensitive habitats, wildlife, ecology and oceans (Sheavly, 2010). It also threatens the culture, the economy, people around the world and the inhabitants of coastal and riverine communities (Sheavly, 2010).

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A recent report from the National Academy of Sciences on marine debris concluded that there was still relatively little information available on the quantities and sources of marine debris, encouraging the implementation of coordinated monitoring efforts to assess marine debris (Sheavly, 2010).

The performance of monitoring activities to evaluate the types and quantities of microplastics, help to have a description of what is and in what quantities. According to GESAMP (2015) more information on the fragmentation of PE, PP and EPS plastics should be collected; design sampling strategies to establish temporal trends and spatial trends in selected marine areas; evaluate the possible risk of microplastics for the health of humans and examine the accumulations of microplastics.

Investigation questions

1. What kind of microplastics are found on the beach of Guancha de Ponce Puerto Rico?
2. What is the difference of the amount of microplastics in the beach of Guancha de Ponce Puerto Rico and the sampling quadrants?

Literature review

The research conducted by McDermid & McMullen (2004), showed the presence of small plastics waste on the beaches of the Hawaiian archipelago. Nine remote locations along the Hawaiian Islands were sampled between September 2001 and February 2003. At each beach a sediment sample was taken from the high tide line. Nested sieves of 4.75, 2.8 and 1 mm were used. Only particles of 1 - 15 mm in size were retained.

The classification consisted of dry type, where each sample was placed on white paper. It was classified as plastic, plants and "others" (ie, shell, paper, and ceramic matter). They were placed in separate containers, then labeled with the size, location and type of sieve. The second step is a wet type where each sub-sample of plastic is rinsed to remove sand. Then, small amounts of sample are poured into a container of fresh water. The container was swirled for 1 minute and the floating particles (plastic) were sieved.

The samples were dried in an oven for 1 hour at 65 ° C. The third and last step was to classify and quantify, each size class was separated by type of plastic, counted and placed in separate containers.

As a result, a total of 22 samples were collected. Of the 736.47 g collected waste, 72% by weight were plastic particles, 22% vegetative material and 6% "other". Small plastics waste was found in each sample, totaling 19,100 pieces. After being classified, 87% of the plastic collected were fragments, while 11% were pre-production plastic granules. The total weight of the plastic for all the combined sites was 532.37 g. Significant amounts of small plastic debris (1-15mm in size) were found on all beaches from which samples were taken.

It should be noted that each beach had different current patterns, types of sand, wave action and exposure to the wind. This type of plastic pellet is abundant on beaches in areas close to plastic factories, loading docks and boarding lanes for raw plastic materials. The collections of the high tide line contained much more plastic than berm samples, perhaps because the particles suspended in the water will remain on land during each receding tide, while berm waste is deposited mainly during storms or as traces washed away the wind of the high tide line. The authors concluded that the effects of small plastic debris on marine animals, including the toxicity of granules and fragments that accumulate on beaches throughout the Hawaiian archipelago, remains unknown, but should be investigated.

In a study conducted by Yu, Peng, Wang, Wang and Bao in 2016, microplastics were investigated in the Bohai Sea sand in northeastern China. The objective of the research was to provide data on the abundance and chemical composition of micro plastics. Therefore, sand samples from three sites in the northern Bohai Sea were quantified and characterized to analyze micro plastics.

The study consisted of four steps: Collections of field sampling, isolation and quantification, verification and characterization of micro plastics; and finally, statistical analysis. Sand samples were collected from three locations north of the Bohai Sea from July 25-27, 2015.

At each site studied, samples were taken from two sites, the commercial and non-commercial beach. The beach for bathers where there is commercial activity and is visited by approximately 800 thousand tourists in summer; and the beach for non-bathers where there is no commercial activity.

All materials were collected by a metal ring with a diameter of 25 cm and 2 cm in height. In addition, the vertical distribution of the micro plastic was investigated so that 5 more samples were collected below the surface samples with a depth of 20 cm. In the second procedure, all the samples were dried at 50 ° C for at least 48 hours and 50 g of the dry sand was mixed with 250 mL of saturated saline for 2 minutes. After 2 hours of settling, the water solution on the sand was transferred to a 500 mL beaker for another settling hour. Then the solution was filtered through a 47 mm glass fiber filter with 1.0 mm pore size. The filters were dried for 24 hours and sealed in Petri dishes for quantitative and qualitative analyzes.

To quantify the number of fragments an AM3011 digital microscope with a magnification of 70x was used. All suspect microplastics were classified into fragment, sheet and fiber. The results of the abundance and composition of microplastics indicated that a certain portion of non-plastic material consisting of fibers was detected in the samples. These fibers include artificial and natural celluloses. The abundance of microplastics was 102.9 ± 39.9, 163.3 ± 37.7, and 117.5 ± 23.4 "items" / kg. Eight types of plastics were found in the sand samples. The three most abundant plastics were PEVA, LDPE and PS. PEVA plastic is found in bathing and waterproof curtains. In the plastic bags and dispensing bottles is the LDPE material. On the other hand, PS plastic is used for protective packages such as containers or peanut wraps.

The two possible reasons that the authors proposed for microplastics were the high density of industries and urbanizations in the region, or the geographic structure of the Bohai Sea that promotes the accumulation of microplastics. Even in the majority of the samples, the colored fibers that come from the wastewater of the washing machines predominated. Each garment produces> 1,900 fibers per wash.

These fibers are confused with microplastics because of their similar shape and the difficulty of identifying them without a microscope. Cellulose fibers are not classified as plastic despite having the capacity to absorb toxic contaminants; and they are found in dresses, coats, pants or any item of clothing. It should be noted that 90% of non-plastic particles were fibers and FTIR results indicated that most were cellulosic fibers.

The results showed that the verification of the FTIR combined with SEM was able to separate the artificial cellulose as cotton threads from the plastic fibers. Then, due to the high tourist activity in the studied sites, the bathers beach showed more abundance of micro plastics than the non-commercial beach. Yu, Peng, Wang, Wang and Bao (2016) demonstrated in their results that the 2 cm deep surface has a slightly higher abundance of microplastics compared to the 20 cm deep samples; it also contains more microplastics than the noncommercial beach evaluated (Yu, Peng, Wang, Wang, & Bao, 2016).

In another investigation of microplastics, carried out by Tanaka and Takada (2016), they evaluated microplastic fragments and microspheres in digestive tracts of planktivorous fishes of urban coastal waters. Plastics were captured in Tokyo Bay who receive water from the river, industrial wastewater, and surface runoff from the city.

In this research, plastics were studied in personal care products to determine the characteristics of micro plastics that are used. For this, they bought brands of facial cleansers where polyethylene is used. In addition, the Anchoa fish was examined or under its scientific name Engraulis Japonicus, since it is an important food for humans and even organisms. Scientists have observed physical impacts on the digestive system and deterioration of feeding capacity due to the ingestion of micro plastics in these fish. The intake of microplastics in this species is worrisome, since they contain dangerous chemicals to which humans are exposed.

The study method consisted of three steps. The first step was sampling and processing. Then classification and identification of plastics. Finally, the examination of micro spheres in cosmetics and personal care products.

To begin the sampling and processing study, they captured 64 anchovies in Tokyo Bay in a span of 7 hours. After measuring them, they removed their digestive tract and placed them in a 10 mL glass bottle that was baked at 550 ° C for 4 hours. To digest organic matter, a 10% solution of KOH is inserted from 7-8 mL (> 3x of the bowel volume). They were covered for 10 days until the digestion was completed in 3 to 4 days. The bottles were shaken in order to break the mass of non-digestible materials such as zooplankton shells and those that remained floating separated in another bottle. They were examined under a microscope and particles similar to natural prey were determined.

In the second step used was the classification and identification of microplastics, photographing the particles that remained floating in the intestinal tract of the fish. They analyzed those suspicious plastic pieces by infrared spectroscopy to identify polymers. Twelve particles were identified as being of natural origin, eleven of them were not identified and the rest was classified as synthetic polymers. Finally, in the third step they examined the plastics of the hygiene products that they bought to determine the properties of the micro spheres. The marks that were examined contained polyethylene. They were mixed with distilled water and floating solid particles were identified by FT-IR

The results showed that there were microplastics in the digestive tract in 49 of 64 anchovies. Of the 150 pieces of plastic, 129 were fragments, 11 balls, 8 filaments 2 "foams". The plastics consisted mostly of polyethylene and most were white or transparent. The results of the plastic particles of facial cleansers report that the 4 products contained micro spheres of polyethylene. To conclude, the researchers could not identify the origin of the fragments, but it can be part of a history of degradation in the environment. The results confirmed the presence of polyethylene particles in the four brands of facial cleansers in Japan and micro spheres in two of them. Polyethylene was found in fish and its appearance coincided with that of facial cleansers. The observations confirm that micro plastics have been introduced into the marine ecosystem. These small fragments absorb hydrophobic chemicals from salt water as well as contain compounds during their manufacture.

The human intake of micro plastics through anchovies can increase the body burden of hazardous chemicals, so, we are exposed to chemicals as well as anchovies.

In the studio of Reisser, Shaw, Hallegraeff, Proietti, Barnes, Thums, Wilcox, Hardesty, and Pattiaratchi; the types of organisms that inhabit the surface of 68 small floating plastics from coastal waters of Australia, whether tropical or temperate, were examined to characterize their biodiversity. The Scanning Electron Microscope SEM was used for the study. The variety of plastic forms and textures have interacted with environments and marine organisms that can physically affect the feeding deposits of the fauna; for example, blockages after ingestion. It can even alter pelagic biological life and modify the physical properties of its habitats. In addition, microplastics can transport species, changing their natural ranges to convert them into non-native species, including invasive pests.

To begin the study, 65 floating plastics were selected between> 1mm and <10mm to fit in the scanning electron microscope, and were preserved in 2.5% glutaraldehyde buffered in filtered seawater. They were dehydrated with increasing concentrations of ethanol, dried at critical points using CO2, mounted on aluminum pieces with carbon tape and then powdered with a layer of gold. The types of organisms detected in each piece of plastic were measured and classified into taxonomic and morphological groups; In addition, the frequency of occurrence for each type was calculated. Each piece of plastic was photographed with a magnification of 50x to measure the parameters of size and shape, observe the superficial fractures, the holes and the grooves. After the analyzes, the plastics were washed with distilled water and subjected to infrared spectrometry of the Fourier Transform to identify polymers.

As a result of the 65 hard plastic fragments, they had a diverse range of shapes and types of surface micro textures, including linear fractures, holes and scraping marks. The fragments were made of polyethylene (54) and polypropylene (11). Diatoms and bacteria were observed in all the marine regions sampled. However, the diatoms, specifically the genus Nitzschia, were the most abundant, widespread and diverse group of plastic colonizers.

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Several unidentified organisms of morphotypes and sizes were found, mostly resembling bacteria, cyanobacteria and fungal cells. Frequently elongated cells were observed and were detected in 59% of the plastics examined. In addition, some invertebrates were observed in millimeter-sized plastics. Encrusting bryozoa colonies were the most common animals. Four of these colonies harbor diatom assemblages dominated by Licmophora Sp, Nitzschia Longissima, Amphora Sp and Nitzschia Sp. Even an unidentified sea worm was found in a 6mm plastic fragment.

Now there is ample evidence that millimeter-sized plastics are abundant and widespread in marine environments. This study showed that the number of known genera of diatoms that inhabit marine plastics doubled. These diatoms fixed firmly the plastic, they resisted the turbulence of the water and the action of the wave. This study showed that micro plastics provide a new niche for other types of microorganisms and invertebrates.

Methodology

The samples were analyzed on the beach according to the protocol of the 5 Gyres Institute (5 Gyres).

1. The 200 meter measuring tape was placed parallel to the ocean. To randomly evaluate microplastic contamination in the area, four random zones were selected between 0 and 50. Then, a random quadrant was placed on the middle beach or trail every 50 m of transept.

2. In each quadrant, pieces of natural debris such as seaweed, leaves and wood were removed.

3. Sieving of dry sand:
a. Half of the 5-gallon bucket was filled with sand, scraping the surface of the quadrant evenly, using a flat cup or dustpan. It was approximately 3 cm (in depth) of the entire surface within the quadrant. The sediment was scraped off the surface as evenly as possible.
b. Once the bucket was half full, the sediment was removed from the bucket and poured into the 1 mm sieve. All contamination of plastic and other non-natural waste was placed in a sample jar or bag.

4. Wet sand screening:
a. The wet sand was poured into a wide, flat container.
b. Once the sand was spread evenly, it was left to rest for a day until it was completely dry.
c. Return the sand to its respective bucket and start sifting.

5. The magnifying glass was used to identify the plastic. To differentiate the plastic material from shells was used the technique of squeezing with the intention of observing if the shell breaks.

6. All the plastic pieces were placed on graph paper (if possible, let it dry somewhere without disturbance). The rule or graph paper was used to separate the plastic pieces in size and categories:
a. Size categories - (particles> 5mm), (particles <5mm)
b. Type of categories - (Fragment, "Film", "Foam", Pellet, "Line")

7. The number of plastics for each category was quantified and recorded in the data sheet.
a. The sample was photographed for the posterior shape, size, color and type of identification.
b. b. The information was sent to citizenscience@5gyres.org and Marine DebrisTracker.

Location

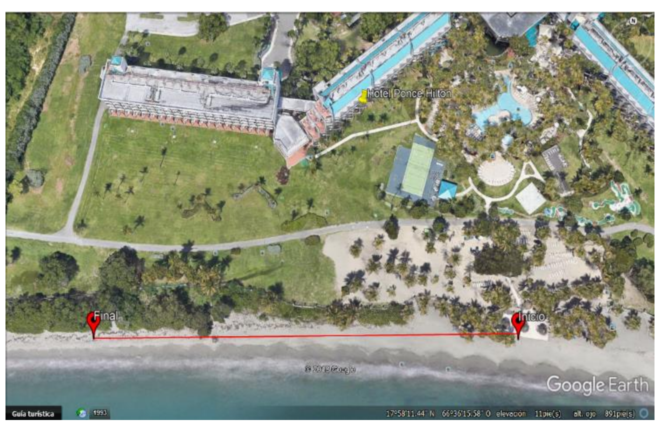
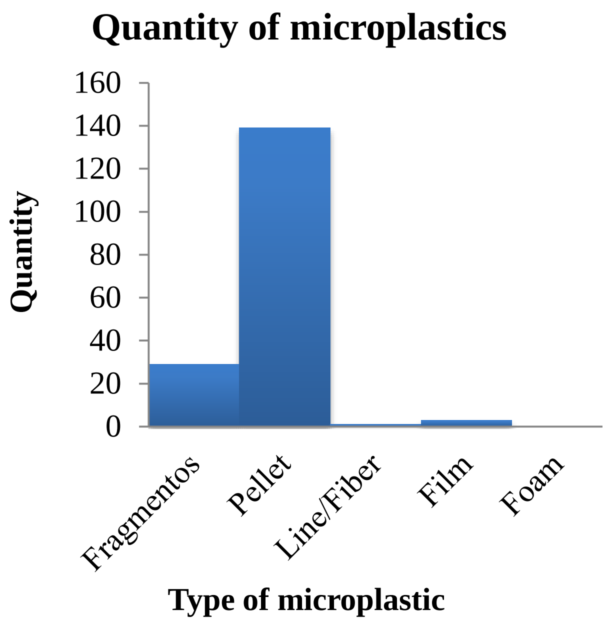


Figure 1 Image taken from Google Earth 2018

Results



Graph 1 Total description of microplastics for five months

To discuss the research question: What kind of microplastics are found on the Guancha beach in Ponce Puerto Rico?

Based on the descriptive and inferential results of the research, the presence of different microplastics is demonstrated in the coast of Guancha de Ponce, Puerto Rico. The most abundant type of plastic micro found in this research was the pellets, which predominated in the quadrants during the five months of sampling. This type of micro plastic, pellet, is found in hygiene products such as exfoliators or granular toothpaste that have a composition based on synthetic developments (Sabaté, 2016).

Another abundant category of microplastics found in the investigation were the fragments; those of greater length were found in the month of November 2017 and February 2018. Secondary microplastics are fragments generated by the decomposition of larger pieces. The fragmentation of plastics in the sea occurs through photodegradation, physical impacts and other processes, and results in the generation of a greater number of smaller particles (Tanaka & Takada, 2016).

As for the category of fibers and filaments, they were found in February in smaller quantities. According to Masura (2015), the fibers that come off synthetic clothing and rope are micro-plastics that also end up in bodies of water. The production of plastics has increased exponentially since the beginning of the 1950s, reaching 322 million tons in 2015 (Lusher, A.L., Hollman, P.C.H., Mendoza-Hill, J.J., 2017). This figure does not include synthetic fibers, which accounted for an additional 61 million tons in 2015 (Lusher, A.L., Hollman, P.C.H; Mendoza-Hill, J.J., 2017). To discuss the research question: What is the difference in the amount of microplastics at the Guancha beach in Ponce Puerto Rico and the sampling quadrants?

A nonparametric test was carried out for three or more independent samples. As the results obtained from the Kolmogorov-Smirnov test confirmed the assumption of non-normality of the data, the Kruskal Wallis test was carried out. The researchers found that the data were less than 0.05, which indicated that they do not follow a normal distribution (See Table 1).

The Kruskal Wallis test was carried out to test whether there is no significant difference in the amount of micro plastics in the Guancha beach of Ponce Puerto Rico and the sampling quadrants. The results of the test were not significant, $\chi 2$ (N = 20) = .1.883, 4.762 p = .792. This p-value, when compared to a significance of 0.05 ($p > 0.05$), indicates that the null hypothesis is not rejected. Therefore, there is no significant difference in the amount of micro plastics in the Guancha beach of Ponce Puerto Rico and the sampling quadrants (see Table 2).

In Table 3 it is observed that the average ranges between the quadrants are similar. According to the sampling and analysis of these, it was demonstrated that there was not a significant quadrant with more microplastics than another one in the coast of La Guancha in Ponce. That is, microplastics were found along the coast during the months of November 2017 to March 2018.

Normality test

Normality test of Shapiro-Wilk			
	Statistical	gl	Sig.
Micro plastics	.550	20	.000
Mass	.678	20	.000

Table 1 Normality Test

Statistical test[a,b]		
	Microplastics	Mass
Chi squared	1.883	4.762
gl	3	3
Sig Asymp.	.597	.190
a. Kruskal Wallis test		
b. Group variable: Quadrants		

Table 2 Kruskal-Wallis test

Ranks			
	Quadrants	N	Average range
Microplastics	1	5	7.80
	2	5	11.70
	3	5	12.50
	4	5	10.00
	Total	20	
Mass	1	5	6.00
	2	5	10.10
	3	5	12.30
	4	5	13.60
	Total	20	

Table 3 Range descriptive test

Conclusion

Based on the descriptive results (Graph 1) and inferential results of the research (Table 2), the presence of different microplastics in the coast of Guancha de Ponce, Puerto Rico is demonstrated. The most abundant type of microplastic found in this investigation were the pellets, then the fragments, fibers and filaments. Based on the statistical test (Table 2) it is concluded that during the months that the microplastics were analyzed on the Guancha de Ponce coast, there is no significant difference in the amount of microplastics found in the sampling quadrants. That is, microplastics were described in all the quadrants during the months of the study.

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