PAMS

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Saving our Seas: Restoring our marine systems for people and nature

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On the cover:

This Special Issue pays tribute to the research presented during the 17th National Symposium on Marine Science, which was organized by the Philippine Association of Marine Science. The event's theme, "Saving Our Seas: Restoring Marine Systems for People and Nature," reflects a shared commitment to safeguarding our marine ecosystems.

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International Research Journal on Innovations in Engineering, Science and Technology

Assessing microplastic contamination in typical coastal waters: Evidence from sediments, surface water, and fish

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ABSTRACT

Plastic pollution is one of the most well-known anthropogenic pressures in the marine environment. Since plastic does not truly biodegrade, it breaks down into tiny pieces known as microplastics (MP), which account for a sizable number of tons of trash in the oceans. The study was conducted to observe MPs obtained from three different samples, such as sediment, surface water, and fish at Aplaya, Bauan, Batangas, Philippines. Apart from this, it aimed to know the difference among the types and number of MPs in the samples in the said location. The samples were collected within three consecutive sampling periods within a month. Specific amounts of chemicals were used based on the sample size of each sample, which helped digest the organic matter, wherein potassium hydroxide (KOH) was used for sediment and surface water. Whereas KOH, hydrogen peroxide (H_2O_2), and Iron (II) sulfate ($FeSO_4$) were used for fish samples. It was observed that there is a high number of fragments, a small amount of foam, and no pellets at all in three samples. A total of 452 MP pcs were recorded in sediment, 321 pcs in fish, and 98 pcs in surface water. Proper disposal of glass bottles should be utilized, as fragments have the highest number found in all samples. Further study about MPs is recommended to come up with a newer method to identify MPs in terms of their form, composition, and type.

Keywords: fibers, film, foam, fragments, microplastics, pellets

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1. Introduction

Water is rapidly filling up with plastics, which makes plastic pollution one of the most well-known environmental problems. Since plastic does not degrade but instead breaks into tiny fragments, it results in MPs (MPs), which make up a significant portion of the millions of tons of garbage in the oceans [1]. MPs can be found in a variety of places, as it is from a bigger plastic waste down into smaller fragments, whose size varies between 1 mm to less than 5 mm [2]. MPs can be considered as primary and secondary based on their sources [3]. Primary sources, which are commonly from cosmetic and consumer products [4], while secondary sources are from large plastics that break down into smaller pieces [2]. One of the examples of primary sources is microbeads, which are extremely small bits of manufactured polyethylene (PE) plastic, that are used as exfoliants in health and beauty products, such as cleansers and toothpaste [1]. Thus, the best example of secondary plastics is those plastic bags used by consumers in the market [2].

Most people believe that the ocean is one of the last places where plastic and MPs fall to the ground, yet incorrect trash disposal causes both large and tiny plastics to end up in the marine environment [2]. These microscopic particles easily bypass water filtering systems and end up in the ocean and lakes, posing a risk to aquatic life and humans. Given that MPs are spreading throughout the world, they have an irreversible effect on biodiversity and the overall geochemical cycle. Also, aside from marine organisms getting entangled in plastics, marine organisms may suffer damages if they unintentionally consume plastics as food [5], such as reduced eating and higher uptake of some pollutants [6]. It was also stated that microfibers (another form of MPs) may also clog the digestive tract of some marine species [2]. Thus, MPs imply harmful effects on wildlife as well, which cause false fullness when ingested [4]. Accordingly, it has been recently investigated that high MP concentrations in the marine environment have ecotoxicological consequences on marine life [3], which can increase the production of toxic reactions in organisms cell membranes [5]. Furthermore, MPs can prevent gas exchange, which can result in anoxia or hypoxia and harm marine organisms [5]. As a result, the presence of MPs in marine species intended for human consumption, as well as the high consumption of seafood in some countries, raises concerns about MPs' potential health impacts, including cancer, body system disorders, and many more [7].

People today live in a world where plastics are abundant as they are utilized in daily life, which leads to a high level of plastic production and consumption [3]. The human race has created nearly eight billion metric tons of plastic since mass production began 60 years ago. Only 9% has been recycled, with the remaining 12% being destroyed [1]. The rest, about 80% of all plastic ever produced, winds up in landfills or the natural environment, eventually contaminating rivers, streams, and oceans [8]. The Philippines is one of the overpopulated countries that produces more plastic for the needs of humans in daily life. It is pointed out that the number of undissolved plastics in the large bodies of water in the

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Philippines is about 80%, making the different bodies of water contaminated by MPs [6].

MPs have a wide range of effects on the ecosystem, and humans still do not fully comprehend these. Approximately 0.75 million metric tons of improperly managed plastics enter the marine environment each year, and one of the largest contributors is the Philippines [9]. With this, there has been an increase in the awareness of plastic waste management in the Philippines, bringing the issue of plastic pollution to the forefront of consumer consciousness. The Philippines, like many other fast-developing countries, struggles with unsustainable plastic manufacturing and use, as well as inadequate solid waste disposal infrastructure [10]. Every year, the Philippines generates an astounding 2.7 million tons of plastic garbage, with an estimated 20% of it ending up in the ocean [9].

Batangas City, with its tens of thousands of residents, is one of the most densely populated cities in the Philippines [11]. It is commonly known that plastics are used for packaging in enterprises, food franchises, and restaurants. Also, it is stated that there is no exception for the transportation of goods, which was more popular during the pandemic, like packaging online orders, making plastic production and plastic waste increase [2]. With the said increase in plastics, Batangas developed a no-plastic ordinance to discontinue the usage of plastic as packaging in all areas, may it be in wet markets, shopping malls, or food stalls [12]. The city's decree had already been expanded to the province's smaller municipalities and cities such as Tanauan, Lipa, and Rosario. Thus, developing a plastic ordinance will promote a healthier lifestyle in the future and protect the ecosystem.

In Aplaya, Bauan, Batangas, it was observed that garbage was not well disposed of and was only placed on the seashore. Some garbage was placed exactly in the water, which is disturbing since the study site was one of the fish resources of Batangas. The objective of the study mainly focused on the identification and quantification of MPs that can be found in fish, surface water, and sediment in Aplaya, Bauan, Batangas, Philippines.

2. Materials and methods

2.1. Study site

This study was conducted in Aplaya, Bauan, Batangas, Philippines (at roughly 13°46.815” N, 121°00.391” E). In addition, the site has a population of about 7,837, which represents 8.63% of the total population of Bauan [13]. Visual observation of the site showed a populated residential area, which explains the presence of different trash around the area (Figure 1). The most common type of trash seen in the area were glass bottles, Styrofoam, plastic bags, and plastic containers. Though trash bins are available in the area, people still pile garbage near the seashore, and some do not know how to throw trash in the right place.

Figure 1. Images of the shore of Aplaya, Bauan, Batangas on May 3, 2025.

2.2. Sample collection

MPs were identified and collected from different sources such as sediments, surface water, and fish within three consecutive sampling periods last September 2022. The sediment was collected at the intertidal zone of the sampling site. Thus, a water sample was collected at the intertidal zone as well, and the pre-cleaned containers or sieves were immersed between 10 cm to 100 cm. Fish samples, *Selar crumenophthalmus* or Bigeye scad, were collected as it was the common fish in the study area during the collection. These methods were modified in the equipment and process used in the study, where observation of forms of MPs was focused compared to the use of Fourier transform infrared (FTIR) spectroscopy, where composition and types of MPs were observed [14].

Table 1 details the sample measurements in grams from the three-sampling period. For water samples, direct filtration of water samples via sieves in each batch sample is the most widely used method for water sampling and should have a greater sample amount [8]. Thus, random sampling parallel to the water sampling location can be used to gather sediment samples [8]. As stated in the study of [2], using forceps and sieves to directly collect samples from the bottom or coast is also one of the best methods for sampling sediments. Thus, for the size and measurement of fish, it depends on the weight of its stomach to gut parts. It was stated that MPs are consumed of marine species by eating, therefore the digestive tract of a marine species sample is the ideal area to observe [14].

Table 1. Sample measurements from three sampling periods

Samples		Weight	Length	Width
First Sampling				
Sediments		60 g	-	-
Surface water		120 g	-	-
Fish	Whole fish	60.60 g	17 cm	5 cm
	Gut	2.48 g	4 cm	2 cm
Second Sampling				
Sediments		60 g	-	-
Surface water		120 g	-	-
Fish	Whole fish	79.82 g	14.5 cm	4 cm
	Gut	3.60 g	4.5 cm	2.5 cm
Third Sampling				
Sediments		60 g	-	-
Surface water		120 g	-	-
Fish	Whole fish	120.64 g	15 cm	5 cm
	Gut	5.24 g	2.6 cm	1.6 cm

Sampling was performed during the day since MPs tend to pile up across the beach zone during high tide [6]. To avoid contamination, it is important to take extra care with the samples, such as ensuring the container and other materials are sanitized before the experiment, and corrosive liquids should be placed in a separate container and disposed of at the management facility. Although plastics don't biodegrade, they can undergo physical changes as a result of field sampling, environmental weathering, and laboratory processing [14]. Hence, greater caution should be utilized, and observation should begin as soon as samples are collected.

2.3. Sample processing and determination of MPs

Upon arrival in the laboratory, the collected samples were processed immediately. For sediments and surface water samples, potassium hydroxide (KOH) was used to digest organic matter. 10% of the sample size was weighed and computed to prepare KOH for digestion in sediment and surface water [4]. KOH is also ideally adapted to dissolve invertebrates and fish fillets and has been demonstrated to be mostly effective in eliminating biogenic debris [14]. On the other hand, KOH, hydrogen peroxide (H_2O_2), and iron (II) sulfate ($FeSO_4$) were used in digesting organic matter in fish samples. It was proven that plastics eaten by marine species can be studied more easily with chemical solutions that help dissolve organic matter, but most plastic is unaffected [15].

All samples with prepared chemicals were placed in a stirring hot plate at 80°C and 360 rpm for 30 min up to 1 hr [14] (Figure 2). Since MP size range is important for its identification, test sieves were used [3] in sizes that range from 90, 300, and 500 µm. These sieves were used specifically because MPs do not only have one size rather, they range in different sizes, less than 5mm [8]. After filtration, MPs were observed and isolated under the dissecting microscope with the aid of forceps and placed in laboratory containers for storage. Before identifying the forms, the first stage in separating MPs from the samples is visual sorting [8]. Using a microscope for visual assessment is subjective and focuses more on forms [2]. As stated by [14], many researchers employ visual inspection and light microscopes, such as dissecting microscopes, and thus they identify MPs based on shape, color, texture, and size. In addition to that, MPs may be separated using forceps and tweezers; therefore, as plastic is sensitive to heat, MPs can be checked using hot tweezers [14].

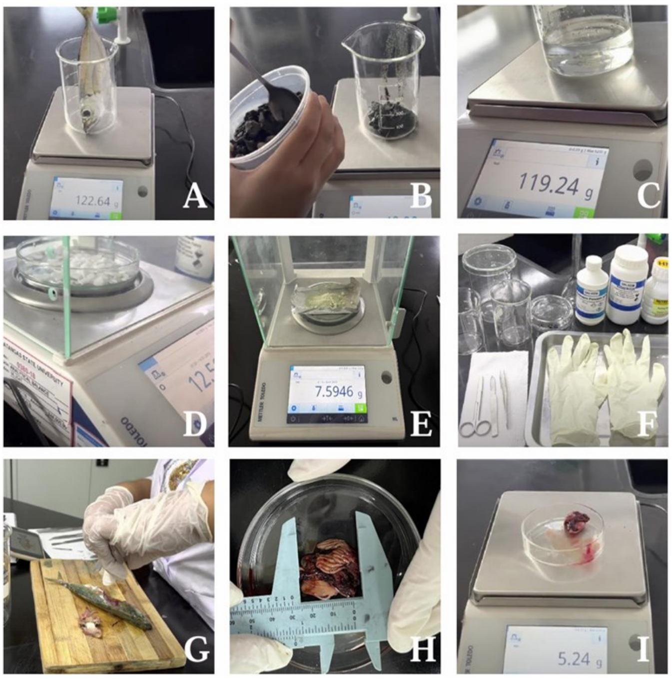

Figure 2. Photographs showing (A) fish sample; (B) 60 grams of sediments in all samples; (C) 120 g of surface water in all samples; (D) potassium hydroxide; (E) iron (II) sulfate; (F) 30% of hydrogen peroxide; (G-I) dissecting and measurement of fish gut sample.

2.4. Statistical treatment

The forms of MPs found in the samples collected from different sampling dates were counted manually. Similarity Profile Analysis (SIMPROF) was used to determine the significant difference in the number and form of MPs obtained from the samples. Dendrograms were used to show similarities and differences among MPs obtained from the samples. The dendrogram used Bray-Curtis data together with SIMPROF analysis to test significance using the R Studio software.

3. Results and discussion

3.1. Form of MPs found in sediment, surface water, and fish samples at Aplaya, Bauan, Batangas.

3.1.1. Film

It was observed from the collected MPs from samples that film is translucent and mostly found in a 500 µm sieve size [3]. Figure 3 shows MPs categorized as film. Based on the observation, film is known to be thin, translucent, supple, and appears in uneven shapes. It is usually from plastic bags and plastic sheets [3]. This type of MP is commonly seen in surface water since it has low density [9].

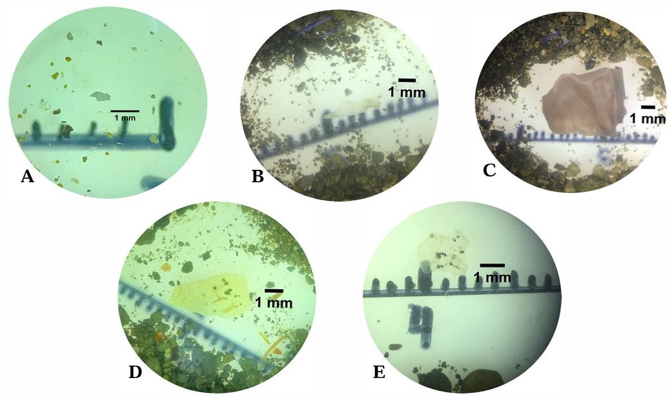

Figure 3. Film: (A) Sample 1, sediments, 90 µm; (B-C) Sample 2, sediments, 500 µm; (D) Sample 3, sediments, 500 µm; (E) Sample 1, sediments, 500 µm.

3.1.2. Foam

The visible foam in the samples ranges in color blue and under a microscope, it looks like a sponge; it was commonly observed at a 90 µm sieve size. It has an irregular shape and appears to be soft under the microscope (Figure 4). Its potential sources are Styrofoam, cushioning, and sponges [3]. MPs in the form of foams are also considered soft plastics [8] as they can easily be broken.

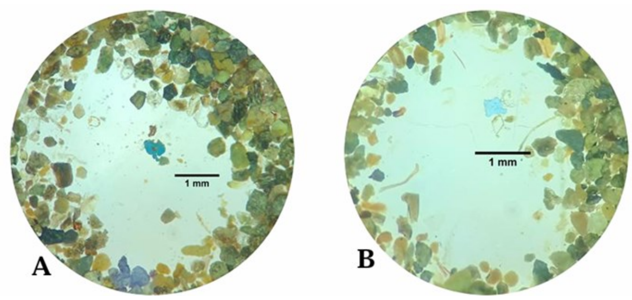

Figure 4. Foam: (A-B) Sample 3, sediments, 90 µm.

3.1.3. Fragments

Under observation, it is seen as small pieces of glass, subrounded, and have broken edges. It was observed in all samples and was also visible in all sieve sizes. Fragments under the microscope look like crystals, thick, and have sharp edges [8] as seen in Figure 5. It can be from different kinds of bottles and hard, sturdy plastics [3]. Fragments are the most common forms of MPs that can be observed in sediments and surface water [8].

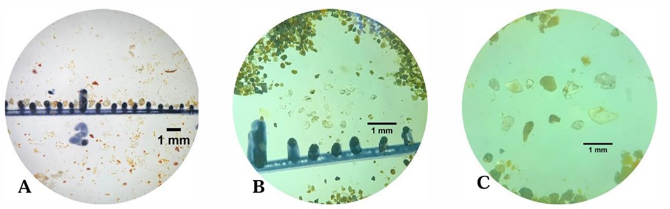

Figure 5. Fragments: (A) Sample 1, fish, 300 µm; (B) Sample 1, sediments, 90 µm; (C) Sample 2, sediments, 90 µm.

3.1.4. Fibers

Fibers can be of different lengths and sizes, and vary between bright colors [8] (Figure 6). Its potential sources are fishing nets and clothes. Like film, it has low density [9] and is commonly seen in fish and surface water [8]. Based on the study, it is commonly observed in surface water and fish samples in all sieve sizes. Fibers, on the other hand, were reported to be present mostly in coastal and deep-sea sediments [12] and can also be affected by the different feeding habitats of fish species [8].

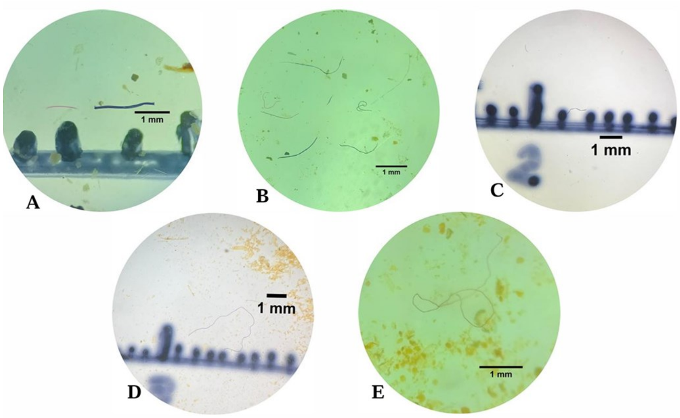

Figure 6. Fibers: (A) Sample 1, fish, 90 µm; (B) Sample 2, sediments, 90 µm; (C) Sample 2, surface water, 300 µm; (D) Sample 3, fish, 500 µm; (E) Sample 3, fish, 90 µm.

3.1.5 Pellets

No pellets were found in the selected area of the study. Overall, the MPs found in Aplaya, Bauan, Batangas are film, foam, fragments, and fibers (Figure 7). In sediments, the total number of MPs obtained was 452 pcs. There are MPs recorded in each form, while no pellets were found in sediments. Specifically, there are 27 MPs recorded in film, 10 pcs in foam, 383 pcs in fragments, and 32 pcs in fibers. The highest recorded form in sediments was fragments, while the lowest counted form was foam. In surface water, the total number of MPs recorded is 98 pcs. There is no presence of foam in all samples of surface water; a total of 6 film pcs were recorded, and the highest recorded MPs were fibers. For fish samples, a total of 321 MPs were recorded, and there was still no occurrence of pellets and foam. The highest form of MP in this sample was fragments, and the film was the lowest form.

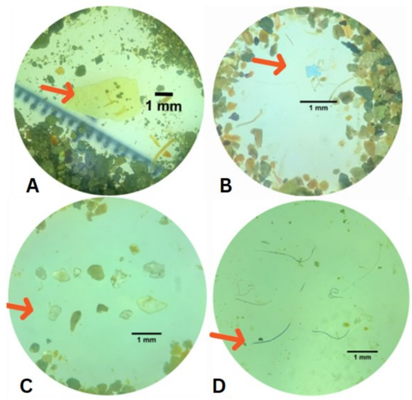

Figure 7. Photographs showing different MPs such as (A) film, (B) foam, (C) fragment, and (D) fibers.

A total of 871 pcs of MPs were isolated and observed from all samples, where all of them consist mostly of fragments, film, and fibers. The common MP found in fish were fibers and fragments. Fragments are commonly found in sediments, and fibers are present in surface water.

3.2. Total average of MPs collected by filter size from the sediment, surface water, and fish samples

Figure 8 shows the total average of MPs from the samples filtered by different sieve sizes. In 90 µm, the highest average of MPs is the sediment, which has 66.67 MPs, next is fish, which has 41 MPs, and lastly, surface water, which has the lowest count, having 16.67 MPs. The highest MP in sediments are fragments and were observed in all sieve sizes. For 300 µm, sediments still have the highest number of MPs, (46.67 pcs), second is fish (42 pcs), and surface water (9.67 pcs). The descending order of the total average of MPs found in a 500 µm sieve is as follows: sediments (37.33 pcs), fish (24.33 pcs), and surface water (6.67 pcs). It is observed that sediments remained to have the highest MP and surface water has the least. MP occurrence in fish samples was also observed in all sieves, since most MPs in fish samples can also be identified in sieves size of less than 5 mm.

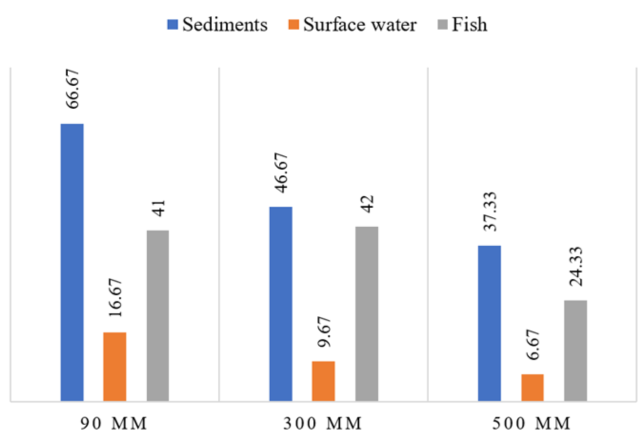

Figure 8. Total number of MPs from all samples in different filter sizes.

3.3. The significant difference among the types of MPs obtained from sediment, surface water, and fish samples at Aplaya, Bauan, Batangas, Philippines

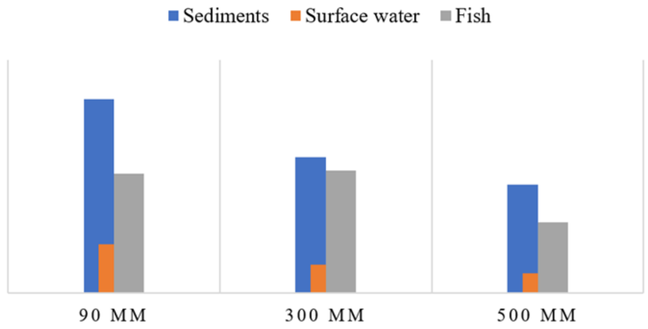

Figure 9. Significant difference among the types of MPs

Figure 9 shows the results of MPs observed from all samples in three different sieve sizes. From all samples, sediments and fish samples were clustered in all sieve sizes. It was concluded that fish in the sampling site are feeding most of the time in sediments where MPs sink [16], which can be consumed by the fish. Based on the results, there is no significant difference in MPs found in sediments and fish, but they are both significantly different in surface water in samples at Aplaya, Bauan, Batangas.

4. Conclusions

Based on the findings of the study, the following conclusions are drawn. First, MP forms such as film, foam, fragments, and fibers are present in all the samples: sediment, surface water, and fish. The highest number of MPs was found in sediment, followed by fish, and lastly surface water. Regardless of sieve size, sediment was found to have the highest MPs, followed by fish, and then surface water. It was also concluded that there is no significant difference in MP content of sediments and fish, but they are both significantly different in surface water samples at Aplaya, Bauan, Batangas.

Research about MPs present in different sizes of fish samples is recommended to fully understand the amount of MP consumption by fish. Since presence of MPs in the marine environment are expected to have hazardous effect on marine species as well as the overall food web due to bioaccumulation, it is also necessary to conduct research on how MPs are exposed to the environment through various sources, such as scattered bottles, glass jars, plastic bags, and bottles. With this, it can help broaden our knowledge about MPs from different perspectives. More research is required to fully comprehend MP contaminants in the environment and their possible consequences on human health.

Educating people about MPs and their impact on our ecosystem and environment is also crucial. It is one of the most effective ways to inform and inspire people to better care for our environment, which will benefit us in the long run. The 3 R's—reduce, reuse, and recycle—are among the finest ways to manage plastic use and waste since people are aware that its production and consumption are out of control these days. Thus, considering how common MPs are in terms of waste and pollution, the usage of biodegradable polymers is also encouraged.

Advanced technology can greatly help in identifying MPs composition and types more easily. For example, FTIR spectroscopy can be used to identify the types of MPs present in samples.

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