JBS
Research Article

Journal of Biological Studies

eISSN: 2209-2560

V. 8, N. 1:95-110, 2025

https://doi.org/10.62400/jbs.v8i1.13675

Microplastic occurrence in brackish water ponds and milkfish in Capiz, Philippines

Dave Mitchelle S. Lantoria, Stephanie S. Pimentel

Capiz State University Burias Campus, Burias, Mambusao, Capiz, Philippines
*Correspondence author: sspimentel@capsu.edu.ph

Received 11 December 2024 | Accepted 17 January 2025 | Published 15 March 2025

Abstract

This study was conducted to quantify and characterize microplastics in the water column, sediments, and milkfish ingestion from Pontevedra, Roxas, Ivisan, and Sapian ponds, aimed to provide a baseline report on microplastic pollution. Microplastic contaminants, such as fragments, pellets, and fibers, were extracted and analyzed from water samples, sediments, and fish tissues. Water column samples and sediments were collected from the field, and fish gills and gastrointestinal tracts were dissected in the lab for processing. The results showed varying levels of microplastic contamination across the four sites. Roxas exhibited the highest total particle count, with 109 particles. Roxas also had the highest microplastic contaminants in sediment samples, with 36 contaminants in 100g of sediment and an abundance value of 0.12 particles/g, mainly fibers and fragments. Pontevedra and Roxas recorded higher microplastic counts in fish gills, ranging from 68-77 particles (1.21-4.28 particles/g). Furthermore, Roxas had significant microplastic ingestion in the Milkfish gastrointestinal tract, with 66 particles (0.59 particles/g), mostly fibers. Site 2 showed higher contamination in tissue samples, with 62 microplastics (0.41 particles/g). Using One-Way ANOVA test, a significant differences were observed across all sites in water and sediment samples. The findings underscore the urgent need for aquaculture policies addressing microplastic pollution to mitigate its ecological impact on milkfish farming and associated human health risks.

Keywords: Capiz, Fibers, Microplastic, Sediments, Panay Island

1. Introduction

Capiz, located in the heart of Western Visayas is widely recognized as the "Seafood Capital of the Philippines" due to its rich aquatic resources and vibrant aquaculture industry. The region is distinguished by its extensive coastline and thriving ecosystems that are capable of growing and rearing a wide variety of aquatic species, including milkfish, mud crabs, tiger prawns, and tilapia, contributing significantly to both local livelihoods and the national economy (Philippine Statistics Authority, 2020). In recent years the Bureau of Fisheries and Aquatic Resources (BFAR) reported that the province of Capiz was responsible for about half of the total aquaculture production in the Western Visayas region. It is estimated that roughly 466,000 metric tons of fish were produced in the region in the year 2020, with Capiz providing approximately 234,000 metric tons. In 2019, the total value of fisheries and aquaculture production in Western Visayas was estimated at around ₱35 billion. Undoubtedly, the region's aquatic resources play a very important role with the province of Capiz being one of the major contributors due to its vibrant aquaculture industry. However, alongside this industry's economic benefits comes an increasing concern over environmental degradation, particularly concerning plastic pollution in the area.

Microplastics are defined as plastic particles that are smaller than 5 millimeters in size and have been gaining increasing attention as pervasive pollutants in aquatic environments (Law & Thompson, 2014). These microplastics are primarily formed through the breakdown and fragmentation of other larger plastic debris that have entered into the environment or to a lesser extent are intentionally created in the form of microbeads for use in personal care products and other applications. Their remarkable durability allows these small particles to travel long distances along waterways causing a significant and alarming threat to marine life and aquatic organisms (Cozar et al., 2014). Studies have shown that microplastics are persistent in marine and aquatic environments and bioavailable to various organisms which leads to adverse ecological effects. Ingestion of these small plastic particles might induce accumulation within tissues of aquatic species leading to both physical and chemical disturbances and eventually may lead to cascade down the food chain, thus affecting human health.

The global issue of plastic pollution is further exacerbated in countries like the Philippines, which has been consistently been recognized as one of the Western Pacific (Westpac) nations with a significant burden of plastic (both macroplastics and microplastics) in its coastal environment (Jambeck et al., 2015). This is primarily attributed to the country's growing population and the projected increase in plastic use and inadequate waste management practices (Ritchie & Roser, 2023). According to estimates, the Philippines produces millions of plastic bags and sachets daily, much of which ends up in waterways and eventually in marine ecosystems, contributing to the escalating problem of microplastic contamination (Bucol et al., 2020). Microplastics have been found globally in both terrestrial and aquatic habitats, as well as the atmosphere (Duis & Coors, 2016).

According to Fadare et al., (2020), the majority of microplastics found in freshwater environments result from several human activities associated with the production and disposal of plastics in the environment, such as improper waste disposal, wastewater from homes, factories, and treatment plants, and activities related to shipping, fishing, and aquaculture. Studies reveal that the concentration of microplastics in aquaculture habitats is typically higher than in surrounding environments (Priscilla & Patria, 2019). Since most aquaculture sites are enclosed or partially enclosed aquatic settings, microplastics cannot be transferred to other places, which results in a buildup of microplastics in the sediment and water column (Chen et al., 2018). Sources of microplastics that can infiltrate aquaculture environments include fish feed, medication, and plastic fishing gear (Zhou et al., 2021). There is also the possibility that trash and garbage will be brought into these water sources by runoff from the land source. Regions with high anthropogenic activity levels home to aquaculture contribute significantly to microplastic contamination. For instance, the study (Priscilla & Patria, 2019) in aquaculture ponds near a river mouth where much trash accumulates resulted in high microplastic abundances of 103.8 ± 20.7 particles/L and 90.7 ± 17.4 particles/L. In a study conducted by Sanabila et al. (2022), the identification of microplastic particles in sediment, water, and milkfish samples from both semi-intensive and traditional fish ponds in Indonesia presents compelling data on the prevalence and characteristics of microplastic pollution in semi-intensive and traditional fish ponds. Additionally, the study conducted by Sembiring et.al. (2019) on the Citarum River, milkfish ponds, and adjacent marine habitats reveals the widespread distribution and persistence of microplastics in both freshwater and marine systems. Moreover, the study conducted by Rahmawati et al. (2020) investigate the presence of microplastic pollution in the Code River and fish in the special region of Yogyakarta, which is an important water source that sustains a range of human activities and natural processes, reveals various concentration of microplastics in different forms including film, fiber, pellets, and pieces.

In the Philippines many research on both macroplastics and microplastics studies have been published, revealing the widespread presence of microplastics in surface water, sediments, and various organisms. Occurrence of microplastics in surface water (Argota et al., 2018; Espiritu et al., 2019; Lumongsod and Tanchuling, 2019), marine sediments (Bucol et al., 2019; Espiritu et al., 2019; Esquinas et al., 2020; Kalnasa et al., 2019), and marine biota such as fishes (Bucol et al., 2019; Espiritu et al., 2019; Paler et al., 2021), mussels (Argamino and Janairo, 2016), and oysters (Espiritu et al., 2019). However, Galarpe et al. (2021) stated that despite microplastic being one of the most persistent pollutants in the aquatic and marine environment today, there remains a concerning lack of comprehensive monitoring initiatives within the country (Jambeck et al., 2015). Thus, it is crucial to collect baseline data on the presence and concentration of microplastics to support the development of pollution mitigation programs and regulations aimed at managing plastic waste in the country. Furthermore, this research is important because it focuses on Sustainable Development Goal 6: Clean Water and Sanitation, specifically the protection and restoration of water-related ecosystems, which entails preserving and restoring wetlands, rivers, lakes, and other water-related ecosystems to improve their resilience, biodiversity, and ecosystem services. This study aims to assess the level of microplastic contamination in brackish water ponds and the ingestion of microplastics by Milkfish in particular in the municipalities of Pontevedra, Roxas, Sapian, and Ivisan, Capiz. The results will provide valuable insights into the environmental challenges faced by the region and guide efforts to manage plastic pollution while sustaining the economic benefits of aquaculture. By examining the sources, distribution, and impacts of microplastics this research hopes to contribute to the broader initiative of addressing plastic pollution in the Philippines and aid in formulating strategies to protect both the environment and the livelihoods of those who rely on the region's aquatic resources.

2. Materials and Methods

2.1 Study Site

This research study was conducted at four sampling sites in the province of Capiz, Philippines. These sites are established brackish water ponds located in the municipalities of Pontevedra (Site 1), Roxas (Site 2), Ivisan (Site 3), and Sapian (Site 4). Each of these sites represents distinct areas from two districts in the province for consistency and replication purposes; further, three stations were established within each site to facilitate sample collection. The geographical coordinates of these sampling stations are detailed in Table 1.

2.2 Methods

The study followed the protocols prescribed by the National Oceanic and Atmospheric Administration (NOAA) for the isolation of microplastics in water and sediment samples. For Milkfish samples the methods were adapted from Lusher et al. (2017) and Hidalgo-Ruz et al. (2012), focusing on tissue, gill, and gastrointestinal tract (GIT) extraction and analysis.

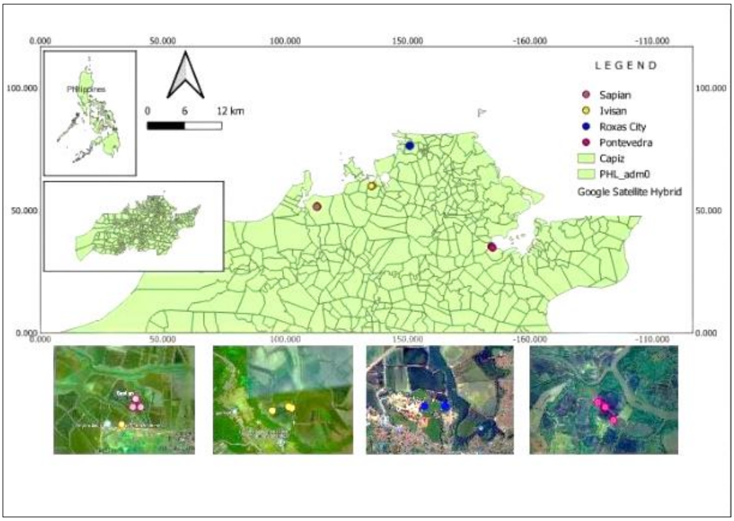

Figure 1. Map of Capiz, Philippines, showing the four brackish water pond sampling sites.

Table 1. Sampling Station Geographical Coordinates and Sampling Points of Brackish Water Ponds in Capiz

Sampling Stations	Sampling Points	Coordinates
S1	P1	11.441995 N, 122.852243 E
	P2	11.441356 N, 122.853259 E
	P3	11.439630 N, 122.854353 E
S2	P1	11.589049 N, 122.731686 E
	P2	11.589855 N, 122.731264 E
	P3	11.589895 N, 122.732663 E
S3	P1	11.5309183 N, 122.6769001 E
	P2	11.5309967 N, 122.6766933 E
	P3	11.5307181 N, 122.675516 E
S4	P1	11.5011563 N, 122.5953199 E
	P2	11.4999950 N, 122.596036 E
	P3	11.500008 N, 122.594905 E

2.3 Sample Collection

Water and sediment samples were collected from the four identified sites and the entire collection took place in one day, March 2024 at each location. Three different sampling sites were identified after the sampling was completed. A diagonal mix was used to collect water samples from the pond, with 10 liters of water collected at each end of the pond and in the center of the pond along a diagonal or across all stations with a stainless-steel bucket. Water and sediment samples were collected from the four identified sites and all the samples were collected in March 2024 at each location Sampling was conducted on sites and three sampling sites from each pond were identified. Water samples in the pond were collected, with 10 L at either end and in the pond's center along a diagonal or across all stations using a stainless-steel bucket. Before gathering the sediments, water column samples were taken first at the sampling sites to prevent the collection of suspended particles. Using a stainless-steel bucket that has also been thoroughly cleaned before use the water was filtered via pre-washed sieve. Argota et al. (2018), Lumongsod & Tanchuling (2019), and Suresh et al. (2020) have also utilized a bucket for water sampling when the manta net is not suitable for the study areas. This is particularly relevant in cases where macroplastics and large debris are present in the study sites and when there are limitations in terms of area and vessel for sampling. Sediment samples were collected using a metal cylinder with a substrate depth of about 3-5 cm. Stations accessible during sampling were pre-identified and marked as such. Two of these were collected in the main gate opening of the pond, and the remaining sample was collected at the side of the pond. All sediment samples will be separately contained in a stainless container covered with aluminium foil before laboratory analysis to discount plastic-associated interference in the container. The fish were collected based on an age criterion of 5 to 6 months with a sample size of 6 fish from each pond. The fish samples were obtained from the pond during the study's harvest. The sample is promptly weighed, wrapped in aluminium foil, and then placed in a cooler filled with ice.

2.4 Quality Control

Before the laboratory work was done it ensured that all the laboratory glassware was thoroughly washed and rinsed with distilled water to remove contaminants. Every sample preparation process involved includes one control group to confirm the validity of the data collected and to ensure that there is no contamination in each of the samples. In addition, to avoid contamination in the laboratory as much as possible all glassware and bottles were covered with aluminum foil. Microplastics were observed and counted by the same researcher to guarantee the consistency of experimental results.

2.5 Laboratory Analysis

Upon arrival at the CAPSU Burias Science Laboratory all the samples were properly labeled and stored. Contamination prevention and control measures followed standard protocols. The fish samples were weighed and dissected to extract the gills, GIT, and tissue. The gills and digestive tissues were subjected to a digestion process using a 65% nitric acid solution (1:10 ratio of tissue weight to acid volume) for microplastic extraction. Water samples were filtered through sieves with mesh sizes ranging from 5 mm to 63 µm. Sediment samples were dried at 60°C for 48 hours before sieving. Microplastics were extracted using a flotation method with a concentrated NaCl solution (1:3 ratio of sample to NaCl volume) to aid in density separation.

2.6 Microplastic Extraction

Fish morphometric measurements (fish length and weight) were performed in the laboratory before dissection. Dissection was done to remove the Gills, GIT, and tissues of Milkfish samples. Each fish sample was subjected to a digestive extraction and weighing procedure. A strong nitric acid solution (HNO_3, 65 percent) was used to degrade, with the gross weight of the digestive tract (g) being matched 1:10 with the volume of HNO_3 (mL) in a 1:10 ratio (Lusher et al, 2017). Water samples were filtered using a stacked sieve net with a 5-mm mesh to 63-micrometer size. The Sediment samples were oven-dried at 60∘C for 48 hours until all the water content was removed following the procedure described by Besley et al. (2017). To make the flotation procedure easier, the dried materials were sieved through a 5mm mesh screen, and a sieve sample of about 100 grams was collected. Microplastic flotation was done after the samples had been weighed. A concentrated NaCl solution in the ratio of 1:3 (water volume (mL) to the volume of NaCl solution was employed to accomplish the flotation of microplastics. The salt solution was also utilized to aid in microplastics' Density separation and flotation. All mixtures were settled overnight allowing the microplastics to float and surface sand to settle at the bottom of the test tubes. For each sample of water, sediment, and fish, concentrated salt solution was allowed to settle for 24 hours to allow for density separation, after which. Microplastic particles were counted for sizes ranging from 63 µm to 5 mm, with particle morphologies including fiber, film, fragment, and granule being counted. The total number of microplastic particles in the environment was also computed and recorded. Each sample was subjected to two counts of microplastic particles.

2.7 Data Analysis

The extracted microplastics were analyzed using a microscope at a magnification range of 10x to 40x. Using previously published classifications. All the particles were classified according to color and form (depending on their physical features). Particles were identified as microplastic based on their size (<5mm), lack of organic or cellular structures, lack of mineral or glass-like characteristics, homogenous color, presence of fraying, and equal thickness throughout their length for fiber-like particles. Microplastics were examined based on their physical characteristics. The microplastic type was determined based on shape and color. Upon obtaining the shape and color of the microplastic in the sample, the abundance of the microplastic obtained was calculated using the determined formula as follows:

a. The formula for the abundance of microplastics in sediment (Rahmadhani, 2019)

$$\frac{\Sigma \text{MP}}{\text{Sample}} \text{X1000}$$

Description: $\sum$MP = Amount of microplastic

b. The formula for the abundance of microplastics in water (Masura et al., 2015)

$$\frac{\text{Amount of Microplastic}}{\text{Volume}}$$

c. The formula for the abundance of microplastics in fish (Boerger et al., 2010)

$$\frac{\text{Amount of Microplastic}}{\text{Amount of Fish}}$$

One-Way ANOVA F-test was used to analyse the differences in microplastic contaminants present in brackish water ponds in each sites.

2.8 Preparation of the Fish Samples for Analysis

In the laboratory, the Milkfish samples underwent measurement dissection and comprehensive analysis. Before dissection the weight and length of each Milkfish sample were measured to obtain data in addition the weight of each sample of the Gastrointestinal tract, Gills and tissues were noted for subsequent examination and evaluation.

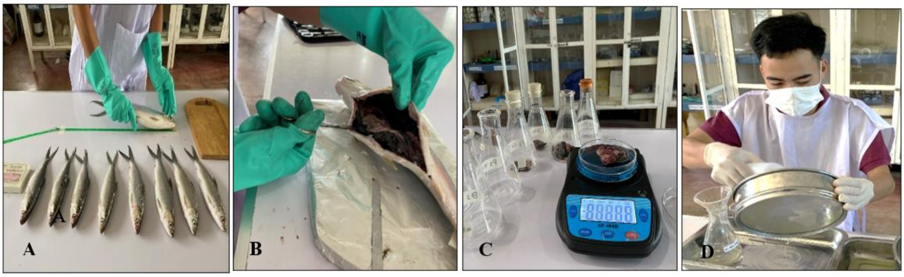

Figure 2. Fish dissection and microplastic extraction process. (A) Fish Morphometric Measurements) (B) Dissections (C) Weighing of samples (D) Filtration)

3. Results

The brackish water ponds at both locations source their water from the nearest river mouths, where brackish water flows through the river channel. This system relies on tidal movements to effectively push water from the river mouths through the river channels into the ponds. As the water travels, it enters a larger open channel that directs the brackish water into the milkfish aquaculture pond.

3.1 Microplastic Types

In this study, various types of microplastics, including fragments, pellets, and fibers, were identified in all samples collected. Figure 3a displays images of the different microplastic types encountered during the research. Fibers were the most prevalent microplastic found across all samples while fragments and pellets appeared in significantly lower quantities. For a detailed overview, Table 2 presents the average number of microplastic particles discovered in milkfish, surface water, and sediment, along with the total average counts and corresponding abundance values. This information underscores the extent of microplastic contamination within the aquaculture environment, emphasizing the need for ongoing monitoring and evaluation of water quality in these ecosystems.

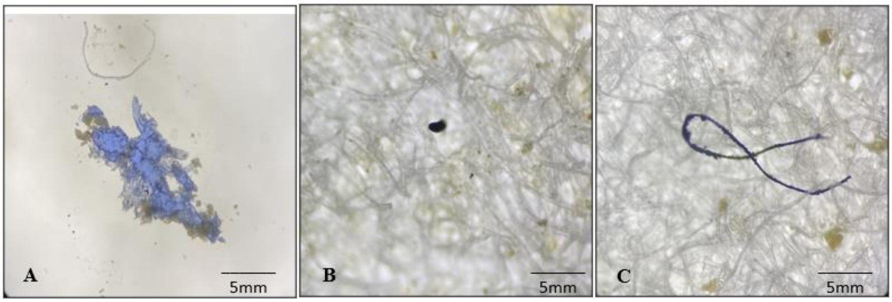

Figure 3a. Photographs of different types and colors of microplastic.
(A) fragments (B) Pellets (C) Fiber

Figure 3b shows that Site 2 (Roxas City) has the highest total microplastic count, with 109 particles, primarily composed of fragments (64) and fibers (44), while pellets are minimal (1). Site 1 (Pontevedra) has a total of 61 microplastic particles, dominated by fibers (37), followed by fragments (15) and pellets (9). Site 3 (Ivisan) has a total of 59 particles, with fibers (28) being the most abundant, followed by fragments (20) and pellets (11). Site 4 (Sapian) has the lowest total, with 16 microplastic particles, consisting of 12 fibers, 3 fragments, and 1 pellet. Across all sites, fragments and fibers are the most common types, while pellets remain the least observed.

3.2. Microplastic Color

Based on the characterization of microplastic black microplastics were the most common in the water column, suggesting the presence of materials and polymers frequently used in black plastic products, such as packaging and industrial materials. Blue and red microplastics were also found, indicating a variety of plastic sources. The variations in microplastic colors highlight the diverse composition of plastic debris, which is often mistakenly discarded and subsequently degraded into smaller particles in the waterways. This kind of color shows that different plastic products contribute to pollution. These plastics likely come from everyday items like packaging and factory waste.

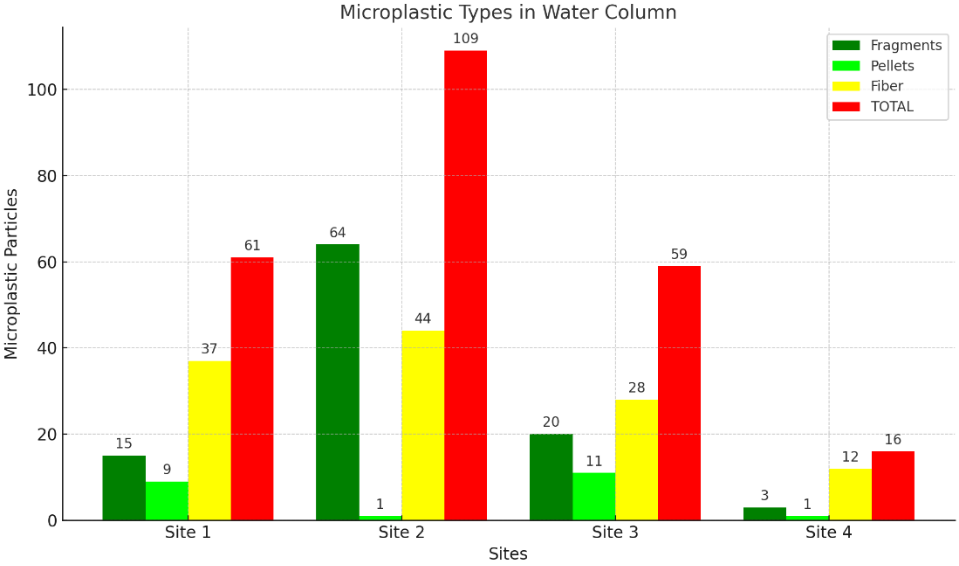

Figure 3b. Summary of microplastic types across sites

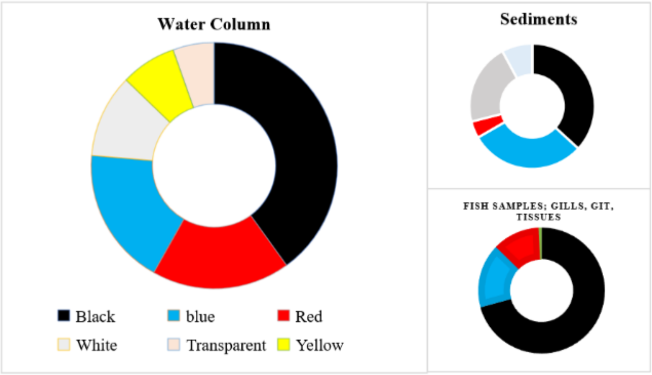

Figure 4. Microplastic colors in different sampling sites

The colors of the microplastics that were obtained from the samples are shown in Figure 4, and they include black, red, blue, transparent, and yellow particles. When compared to other colors, the amount of black microplastics found in all samples is significantly higher than others, with transparent microplastics showing the lowest amount. It is possible that the colors of microplastics originated from plastic sources that became fragmented over time or that have been exposed to the environment. This is demonstrated by the fact that black microplastics are the most common type of plastic that is discarded in the region.

The photograph shows different types of microplastics found in various samples. In brackish water ponds, microplastics come in many sizes, colors, and shapes. Some are small pieces, while others are long fibers or tiny beads ranging from 63 µm to 5mm in size. They are also a variation of colors like blue, red, yellow, and clear or transparent. This variety suggests that the microplastics come from different sources, such as plastic bags, fishing gear, or everyday plastic items, showing that the ponds are polluted in many ways.

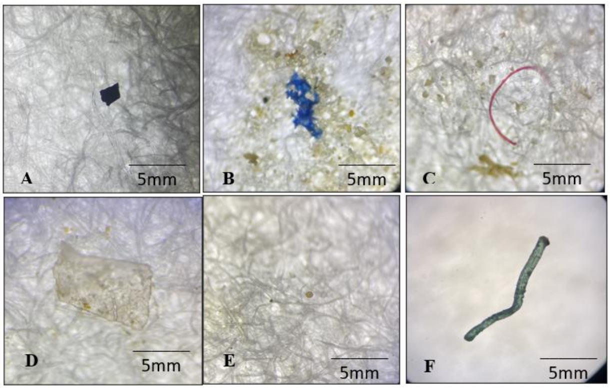

Figure 5. Photographs of microplastics in different colors and types.
(A) Black (B) Blue (C) Red (D) Transparent (E) Yellow (F) Green

3.3 **Microplastic Abundance**

Table 2. Abundance of microplastic contaminants in the water column, sediments, and fish samples such as Gills, GIT, and Tissues.

Sampling Sites	**Average Number of Microplastic Particles**			**Total particles**	**Abundance of Microplastic particles**
	Fragments	**Pellets**	**Fiber**		
Site 1					
Water Column (30L)	15	9	37	61	2.03 particles/L
Sediments (100g)	4.33	0	4.67	9.00	0.09 particles/g
Gills (5.86g)	2.33	1.00	22.33	25.67	4.38 particles/g
GIT (11.65g)	0.33	0	4.00	4.33	0.37 particles/g
Tissues (50g)	0	0	9.33	9.33	0.19 particles/g
Site 2					
Water Column (30L)	64.00	1.00	44.00	109.00	3.63 particles/L
Sediments (100g)	7.67	0	4.33	12.00	0.12 particles/g
Gills (18.69g)	4.00	0	18.67	22.67	1.21 particles/g
GIT (37.61g)	4.33	0	17.67	22.00	0.59 particles/g
Tissues (50g)	0.33	0	20.33	20.67	0.41 particles/g
Site 3					
Water Column (30L)	20	11	28	59	1.97 particles/L

Sampling Sites	Average Number of Microplastic Particles			Total particles	Abundance of Microplastic particles
	Fragments	Pellets	Fiber		
Sediments (100g)	3.33	0	3.00	6.33	0.06 particles/g
Gills (14.14g)	0.67	0	6.00	6.67	0.47particles/g
GIT (26.21g)	1.00	1.00	10.67	12.67	0.48 particles/g
Tissues (50g)	0.33	0	19.33	19.67	0.39 particles/g
Site 4					
Water Column (30L)	3	1	12	16	0.53 particles/L
Sediments (100g)	3.67	0	8.67	10	0.11particles/g
Gills (18.69g)	0	2.67	8.33	0.68	0.11 particles/g
GIT (37.61g)	4.33	0	17.67	22.00	0.59 particles/g
Tissues (50g)	0.33	0	20.33	20.67	0.41 particles/g

The data revealed microplastic contamination across four sites revealing various types and compositions. Site 2 exhibits the highest total particle count, with 109 particles and an average abundance value of 3.63/L, predominantly in fragments and fibers in the water samples. Site 2 also has the highest microplastic contaminants in 100g of sediment samples, with 36 contaminants identified with an abundance value of 0.12 particle/g, mainly fibers, and fragments. Sites 1 and 2 also show higher microplastic counts in gill samples with primarily fragments and fibers, 68-77 particles or 1.21-4.28 particle/g of samples. Moreover, Site 2 shows a count of microplastic ingestion in the Milkfish gastrointestinal tract (GIT), mainly fibers about 66 or 0.59 particle/g of samples. In addition, Site 2 also has higher microplastic contaminants in tissue samples, with 62 microplastics or 0.41 particle/g of tissue samples.

3.4 Variation of Microplastics Contaminants

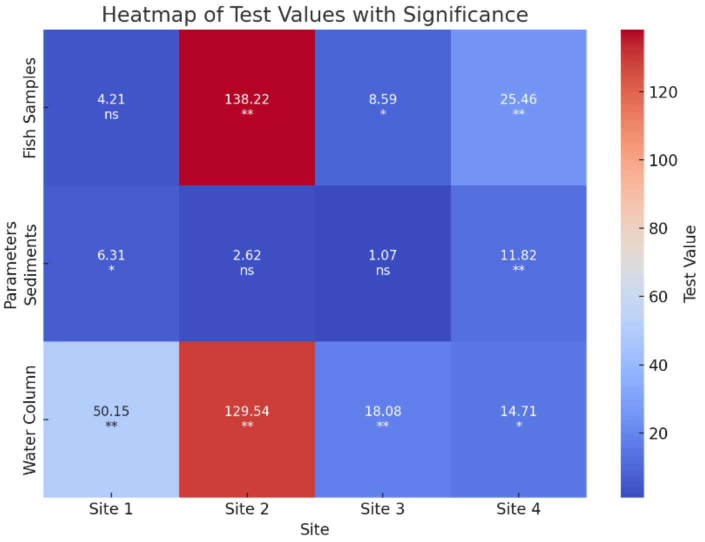

Figure 6. Heatmap of One-Way ANOVA F-test values across different sites and parameters, showing the significance of results. Test values are annotated with significance levels: **Highly Significant (**)**, *Significant (*)*, and Not Significant (ns). The color gradient represents the magnitude of F-test values, with red indicating higher values and blue indicating lower values. Parameters tested include water column, sediments, and fish samples across four sites (Site 1 to Site 4).

The study revealed a notable variation in microplastic contamination across different sampling sites in both the water column and sediment samples. In the water column, highly significant differences were found between all sites indicating that the level of microplastic contamination varied widely from one location to another. Significant differences were specifically observed in sediment samples at Sites 1 and 4 where there are higher contamination levels recorded. However, Sites 2 and 3 showed no significant differences suggesting that there are more uniform microplastic particle concentrations in these areas. In the fish samples, Sites 2 and 4 exhibited highly significant differences in microplastic contamination, meaning that the fish in these areas ingested microplastics at noticeably different rates compared to other sites. Site 3 showed a substantial difference in microplastic contamination, which, although significant, was not as pronounced as the differences seen in Sites 2 and 4. On the other hand, Site 1 demonstrated no significant difference in the microplastic levels found in fish, indicating relatively low or consistent contamination in this site.

4. Discussion

4.1 Microplastic in the Water Column

Microplastic contamination in the water column varies significantly across the four sites. Site 2, with the highest concentration of microplastics, predominantly composed of fragments and fibers indicates a high level of contamination. The presence of fibers suggests that the sources such as aquaculture nets or improper waste disposal of synthetic textiles contribute to microplastic pollution. This implies that Site 2 (Roxas City) posses characteristics that encourages the dispersement of microplastic in water columns. Additionally, population density in the mentioned site is higher than the other sites which could be the reason of increased microplastic contamination. Seasonal variations and human activities, such as the use of plastic packaging, influence the microplastic levels in water bodies, as seen in other studies conducted in the Philippines like in Laguna Lake and the river mouths of Manila Bay show that microplastic abundance changes due to seasonal variations and human activities such as aquaculture and plastic packaging (Osorio et al., 2021; Manalo et al., 2023). Site 4, although exhibiting the lowest contamination levels, still shows the persistent presence of microplastics emphasizing their widespread and enduring nature, even in less polluted environments.

The persistent presence of microplastics in bodies of water, such as the Pasig River highlights the continuous pollution from various sources, including nearby communities and tributaries (Arcadio et al., 2022). Deocaris et al. (2019) identified the Pasig River as a major pathway for microplastics worsening environmental issues linked to urban plastic waste. Similarly, Espiritu et al. (2019) noted that urban runoff and industrial discharges are significant contributors to microplastic pollution, emphasizing the need for effective management strategies in these areas. Their findings underline the serious problem of microplastic accumulation and efforts to reduce this pollution must focus on both its sources and raising public awareness. Microplastics' persistent presence in water bodies indicates an urgent need for action to protect aquatic environments and public health.

4.2 Microplastic in Sediments

Microplastics in sediment samples represent a significant environmental concern as they tend to accumulate and persist in these habitats due to their density and degradation-resistant properties. The assessment of four sampling sites reveals that Site 2 has the highest count of microplastic contaminants mainly fibers and fragments. This could be linked to increased human activity and urbanization as the site is close to both residential and commercial areas where improper waste disposal and runoff of plastic particle are possible. The result aligns with previous research findings, such as the study by Castro et al. (2021) which identified fragments as the predominant microplastic type in marine sediments, attributed to the breakdown of plastic products like food containers and fishing gear. Similarly, Navarro et al. (2022) reported higher microplastic concentrations in sediment samples collected near human settlements, particularly in Nasipit, where fibers from textile sources are mostly found. In contrast, Site 3 in the study exhibited the lowest microplastic contamination, suggesting a cleaner sediment environment. This result could be indicative of effective waste management practices or reduced exposure to plastic sources in the area. Comparable findings were reported in studies by Bonifacio et al. (2022) and Moreira et al. (2016), where microplastic concentrations were lower in less urbanized or environmentally protected regions.

The absence of pellet particles across all sampling sites in the study further suggests that certain types of plastics, such as pellets may not be as prevalent in this region, likely due to the specific nature of local plastic use and disposal practices. This finding contrasts with other studies, such as those conducted in Baseco Port (Castro et al., 2021), where pellets were detected likely due to industrial activities involving plastic pellets. The abundance of fibers and fragments in the sediments particularly in Site 2, reflects the findings of multiple studies. For instance, the study by Sanabila et al. (2022) reported the prevalence of fibers, fragments and filaments in sediments from Sidoaro ponds. The study supports that Fibers type microplastic could also source from textiles fibers and fishing nets (Amelinda et al., 2021), Another source of fiber plastic in the environment could be from fishery activities. The abrasion of abandoned lost, or discarded fishing gear has contributed to marine plastic debris in the marine environment (Andrady, 2011) one of the reasons that fiber can accumulate in the environment because this type of microplastic can last longer on the surface of the water because of its relative density (Lie et al., 2018).

4.3 Microplastic in Milkfish

Milkfish from the sampling sites also show varying levels of microplastic contamination which raises concerns for both environmental and public health. The gills of fish from Sites 1 and 2 contained higher microplastic counts, primarily fibers and fragments, which could be attributed to the role of gills in filtering water and thus accumulating microplastics present in the water column. This indicates that the fish in these areas are consistently exposed to contaminated water leading to microplastic accumulation in their systems.

In terms of the gastrointestinal tract (GIT), Site 2 shows the highest abundance of microplastic particles per gram of fish, with fragments and fibers again being the dominant types. This suggests a notable presence of microplastics in the GITs samples from this site, possibly due to the ingestion of contaminated prey or exposure to polluted environments. In some studies, ingestion of microplastic among fishes could be attributed to their accidental identification of MPs as their prey (Boerger et al., 2010) since these MPs have similar color, shape, and texture to that of food (Lusher et al., 2013).

The presence of microplastics in fish tissue samples, particularly in Site 2 is concerning because it indicates that microplastics have penetrated beyond the digestive system, potentially affecting fish health. The discovery of microplastic fibers in Milkfish tissues also raises the possibility of human exposure through the consumption of contaminated fish. Even in Site 4 where overall contamination levels in the water column were lower, microplastics were still found in fish tissues underlining the pervasive nature of microplastics when introduced into the environment. This finding indicates that the exposure to microplastics is relatively low at this site possibly due to factors like distance from pollution sources or effective local measures to reduce contamination. Microplastics (MPs) intake from fish and shellfish is a major concern in the Philippines. Abiñon et al. (2020) found MPs in commercially sold fish such as *Auxis rochei, Rastrelliger kanagurta*, and *Chanos chanos* in Cebu Island's major public markets. Furthermore, the presence of MPs in seafood increases human exposure risks because marine species consume MPs, potentially transferring them to humans through seafood eating (Danopoulos et al., 2020). The microplastic intake of an organism is related to its feeding habits (Wang et al., 2020). The abundance of microplastic fiber found in all samples suggests that the source of microplastics comes from aquaculture activities such as using of fishing nets and improper disposal of household waste in the area.

The occurrence of microplastics in different environmental compartments has been recorded worldwide, however, few studies are available on the microplastic present in brackish water ponds in the Philippines. This is the first study on microplastics in brackish water ponds in the province of Capiz which serves as an important area for seafood and aquaculture activities. This entails the need for further investigation in monitoring and mitigating microplastic pollution to protect aquatic ecosystems and marine species, such as oysters, mussels, and other key important fishes in the region.

5. Conclusions

This study assessed the existence of microplastics in the water column, sediments, and milkfish ingestion from Pontevedra, Roxas, Ivisan, and Sapian ponds. Site 2 (Roxas City) manifested the highest level of contamination across all the parameters, mainly due to its location within the urban areas, more aquaculture activities, and higher population density. In contrast, Site 4 (Sapian) has comparatively low contamination, which results from the area's directly opposite status compared to Site 2. Moreover, microplastics in Milkfish, particularly in their gills and gastrointestinal tracts, highlight potential risks to human health through its consumption. These results demand immediate actions to address microplastic contamination's environmental and possible public health implications. To mitigate these problems, the local government should implement strict plastic waste regulations, especially in coastal areas where waste could quickly end up in bodies of water. Public awareness can be enhanced to support programs and policies, as well as regular monitoring and further research on microplastics for more evidence-based interventions

Acknowledgments

The authors sincerely thank the local government units of various municipalities in Capiz for permitting this study at designated sites. Special appreciation is extended to the Office of Municipal Agriculture and all individuals who helped connect the researchers with brackish water pond owners. The authors are also grateful to Capiz State University for its unwavering support throughout the research process. Additionally, the authors would like to thank Dr. Edison Roi D. Macusi for his valuable feedback and review of the paper. This collective effort has been instrumental in the successful completion of the study. The authors also would like to thank the reviewers for their comments and suggestions.

Conflict of interests

The authors affirm that they have no competing interests to disclose.

References

Abiñon, B. S. F., Camporedondo, B. S., Mercadal, E. M. B., Olegario, K. M. R., Palapar, E. M. H., Ypil, C. W. R., Tambuli, A. E., Lomboy, C. A. L. M., & Garces, J. J. C. (2020). Abundance and characteristics of microplastics in commercially sold fishes from Cebu Island, Philippines. *International Journal of Aquatic Biology, 8*(6), 424–433. https://doi.org/10.22034/ijab.v8i6.874

Amelinda, C., Werorilangi, S., Burhanuddin, A. I., & Tahir, A. (2021, May). Occurrence of microplastic particles in milkfish (Chanos chanos) from brackishwater ponds in Bonto Manai Village, Pangkep Regency, South Sulawesi, Indonesia. In IOP Conference Series: Earth and Environmental Science (Vol. 763, No. 1, p. 012058). IOP Publishing.

Arcadio, C. G. L. A., Navarro, C. K. P., Similatan, K. M., Inocente, S. A. T., Ancla, S. M. B., Banda, M. H. T., ... & Bacosa, H. P. (2023). Microplastics in surface water of Laguna de Bay: First documented evidence on the largest lake in the Philippines. *Environmental Science and Pollution Research, 30*(11), 29824–29833.

Argota, H. L., Bajado, J. A., Diola, M. D., & Tanchuling, M. N. (2019). Macro-and microplastic pollution in Tunasan River, Metro Manila, Philippines. In *Proceedings of the 4th Symposium of the Asian Regional Branch of International Waste Working Group (IWWG-ARB).*

Andrady, A. L. (2011). Microplastics in the marine environment. Marine pollution bulletin, 62(8), 1596-1605.

Boerger, C. M., Lattin, G. L., Moore, S. L., & Moore, C. J. (2010). Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. Marine pollution bulletin, 60(12), 2275-2278.

Bonifacio, P. S. P., Metillo, E. B., & Romano Jr, E. F. (2022). Microplastic in sediments and ingestion rates in three edible bivalve mollusc species in a southern Philippine estuary. Water, Air, & Soil Pollution, 233(11), 455.Bureau of Fisheries and Aquatic Resources. (2019). *Philippine Fisheries Profile 2019.* Department of Agriculture. https://www.bfar.da.gov.ph

Bucol, L. A., Romano, E. F., Cabcaban, S. M., Siplon, L. M. D., Madrid, G. C., Bucol, A. A., & Polidoro, B. (2020). Microplastics in marine sediments and rabbitfish (Siganus fuscescens) from selected coastal areas of Negros Oriental, Philippines. *Marine Pollution Bulletin, 150,* 110685.

Castro, L. J. A., Monsada, A. M., & Cruz, K. D. (2021). Occurrence of microplastics in the sediments of Baseco Port area at Manila Bay, Philippines. In *IOP Conference Series: Earth and Environmental Science* (Vol. 958, No. 1, p. 012009). IOP Publishing.

Chen, G., Li, Y., & Wang, J. (2021). Occurrence and ecological impact of microplastics in aquaculture ecosystems. *Chemosphere, 274,* 129989.

Cozar, A., Echevarría, F., González-Gordillo, J. I., Irigoien, X., Úbeda, B., Hernández-León, S., ... & Duarte, C. M. (2014). Plastic debris in the open ocean. *Proceedings of the National Academy of Sciences, 111*(28), 10239–10244.

Deocaris, C. C., Allosada, J. O., Ardiente, L. T., Bitang, L. G. G., Dulohan, C. L., Lapuz, J. K. I., ... & Padolina, J. B. P. (2019). Occurrence of microplastic fragments in the Pasig River. *H2Open Journal, 2*(1), 92–100.

Danopoulos, E., Twiddy, M., & Rotchell, J. M. (2020). Microplastic contamination of seafood and implications for human health: A systematic review and meta-analysis. *Environmental Health Perspectives, 128*(12), 126002. https://doi.org/10.1289/EHP7171

Duis, K., & Coors, A. (2016). Microplastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects. Environmental Sciences Europe, 28(1), 2.

Espiritu, E. Q., Dayrit, S. A. S., Coronel, A. S. O., Paz, N. S. C., Ronquillo, P. I. L., Castillo, V. C. G., & Enriquez, E. P. (2019). Assessment of quantity and quality of microplastics in the sediments, waters, oysters, and selected fish species in key sites along the Bombong estuary and the coastal waters of Ticalan in San Juan, Batangas.

Esquinas, G. G. M. S., Mantala, A. P., Atilano, M. G., Apugan, R. P., & Van Ryan Kristopher, R. G. (2020). Physical characterization of litter and microplastic along the urban coast of Cagayan de Oro in Macajalar Bay, Philippines. *Marine pollution bulletin, 154,* 111083.

Fadare, O. O., & Okoffo, E. D. (2020). Covid-19 face masks: A potential source of microplastic fibers in the environment. The Science of the total environment, 737, 140279.

Galarpe, V. R. K. R., Jaraula, C. M. B., & Paler, M. K. O. (2021). The nexus of macroplastic and microplastic research and plastic regulation policies in the Philippines marine coastal environments. *Marine Pollution Bulletin, 167,* 112343. https://doi.org/10.1016/j.marpolbul.2021.112343

Hidalgo-Ruz, V., Gutow, L., Thompson, R. C., & Thiel, M. (2012). Microplastics in the marine environment: A review of the methods used for identification and quantification. *Environmental Science & Technology, 46*(6), 3060–3075.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., ... & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science, 347*(6223), 768–771.

Kalnasa, M. L., Lantaca, S. M. O., Boter, L. C., Flores, G. J. T., & Van Ryan Kristopher, R. G. (2019). Occurrence of surface sand microplastic and litter in Macajalar Bay, Philippines. *Marine pollution bulletin, 149,* 110521.

Law, K. L., & Thompson, R. C. (2014). Microplastics in the seas. *Science, 345*(6193), 144–145.

Lumongsod, S. L. R., & Tanchuling, M. A. N. (2019). Microplastic characterization and analysis in three Makati City creeks. In *Proceedings on the 4th Symposium of the International Waste Working Group-Asian Regional Board (IWWG-ARB).*

Lusher, A. L., Bråte, I. L. N., Hurley, R., Iversen, K., & Olsen, M. (2017). Microplastics in fisheries and aquaculture: Status of knowledge on their occurrence and implications for aquatic organisms and food safety. FAO Fisheries and Aquaculture Technical Paper No. 615. Food and Agriculture Organization of the United Nations (FAO).

Manalo, C. V., Bolante, C. M., & Hizon-Fradejas, A. B. (2023). Microplastics in Northern Laguna Lake's shoreline sediments. *Philippine Journal of Science, 152*(1).

Masura, J., Baker, J. E., Foster, G. D., Arthur, C., & Herring, C. (2015). Laboratory methods for the analysis of microplastics in the marine environment: Recommendations for quantifying synthetic particles in waters and sediments (NOAA Technical Memorandum NOS-OR&R-48). National Oceanic and Atmospheric Administration, U.S. Department of Commerce. https://repository.library.noaa.gov/view/noaa/10296

Moreira, F. T., Prantoni, A. L., Martini, B., de Abreu, M. A., Stoiev, S. B., & Turra, A. (2016). Small-scale temporal and spatial variability in the abundance of plastic pellets on sandy beaches: methodological considerations for estimating the input of microplastics. Marine Pollution Bulletin, 102(1), 114-121.

Navarro, C. K. P., Arcadio, C. G. L. A., Similatan, K. M., Inocente, S. A. T., Banda, M. H. T., Capangpangan, R. Y., ... & Bacosa, H. P. (2022). Unraveling microplastic pollution in mangrove sediments of Butuan Bay, Philippines. Sustainability, 14(21), 14469.

Osorio, E. D., Tanchuling, M. A. N., & Diola, M. B. L. D. (2021). Microplastics occurrence in surface waters and sediments in five river mouths of Manila Bay. *Frontiers in Environmental Science, 9,* 719274.

Philippine Statistics Authority. (2020). *Fisheries situation report: 2020.* https://psa.gov.ph/content/fisheries-situation-report-2020

Priscilla, V., Sedayu, A., & Patria, M. P. (2019, December). Microplastic abundance in the water, seagrass, and sea hare Dolabella auricularia in Pramuka Island, Seribu Islands, Jakarta Bay, Indonesia. In Journal of Physics: Conference Series (Vol. 1402, No. 3, p. 033073). IOP Publishing.

Rahmawati, S., Nuzula, F. F., Sulistyo, E. N., & Hakim, L. (2023, November). Identification of microplastics in fish from the local fish market of Yogyakarta Province, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1263, No. 1, p. 012043). IOP Publishing.

Ritchie, H., & Roser, M. (2023). Ocean plastics: How much do rich countries contribute by shipping their waste overseas?. Our World in Data.

Sanabila, A. I., Hadi, M. I., & Zummah, A. (2022). Identification of Microplastics Content in Sediment, Water and Digestive Channel of Milkfish (Chanos chanos) in Sidoarjo Pond. Al-Hayat: Journal of Biology and Applied Biology, 5(1), 11-24.

Sembiring, E., Fareza, A. A., Suendo, V., & Reza, M. (2020). The presence of microplastics in water, sediment, and milkfish (Chanos chanos) at the downstream area of Citarum River, Indonesia. Water, Air, & Soil Pollution, 231, 1-14.

Wang, C., Zhao, J., & Xing, B. (2021). Environmental source, fate, and toxicity of microplastics. Journal of hazardous materials, 407, 124357.

Zhou, A., Zhang, Y., Xie, S., Chen, Y., Li, X., Wang, J., & Zou, J. (2021). Microplastics and their potential effects on the aquaculture systems: a critical review. Reviews in Aquaculture, 13(1), 71