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Microplastics, Bacterial Isolates, and Antimicrobial Resistance Profiles in *Decapterus macrosoma* from Cavite, Philippines

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Abstract

Microplastic contamination and antimicrobial resistance (AMR) represent emerging concerns in marine ecosystems and seafood safety. This study assessed the presence of microplastics, bacterial isolates, and their antimicrobial susceptibility profiles in *Decapterus macrosoma* (galunggong) collected from Cavite, Philippines. A total of 100 fish were dissected, and stomach contents were processed using potassium hydroxide digestion and wet peroxide oxidation to isolate microplastics. Bacterial identification and antimicrobial susceptibility testing were performed using the VITEK® 2 system, with MIC interpretation based on CLSI M100 (2024) standards. Microplastics were detected in 94% of samples, with individual fish containing between 0 and 4 particles, predominantly fibers. Bacterial isolates were dominated by members of the *Enterobacteriaceae*, including *Klebsiella pneumoniae, Escherichia coli, Raoultella ornithinolytica,* and *Citrobacter freundii*, along with additional isolates such as *Enterobacter cloacae, Proteus mirabilis, Proteus penneri, Aeromonas spp., Pseudomonas aeruginosa,* and *Sphingomonas paucimobilis*. Antimicrobial susceptibility patterns showed high sensitivity to carbapenems, aminoglycosides, ciprofloxacin, and cefepime, with resistance observed to ampicillin, cefuroxime, cefuroxime axetil, cefoxitin, and colistin + polymyxin B. Pearson correlation tests revealed no significant relationship between microplastic count and the number of resistant antibiotics, and Fisher's Exact Test indicated no significant association between microplastic presence and the occurrence of resistant bacteria. These findings provide baseline data on microplastic ingestion and bacterial resistance profiles in D. macrosoma while demonstrating no measurable association between microplastic load and AMR under the study conditions.

Keywords: *Decapterus macrosoma; microplastics; antimicrobial resistance; VITEK® 2; Enterobacteriaceae; coastal pollution; Philippines; bacterial profile*

1. Introduction

The global proliferation of plastic waste has accelerated at an unprecedented rate over the past several decades, transforming plastic pollution into one of the most urgent ecological and public health issues of the modern era. Plastics have become embedded in nearly every facet of contemporary living due to their versatility, affordability, and durability; however, these same characteristics render them persistent pollutants with extensive environmental longevity. Current estimates indicate that millions of tons of plastic waste enter marine environments annually, with coastal nations—particularly those with rapid urbanization, dense population centers, and insufficient waste management systems—contributing significantly to the burden (Talavera et al., 2024; Borongan & Naranong, 2022).

In the Philippines, improper waste disposal, inadequate recycling infrastructure, and continuous urban expansion have intensified marine litter loads, placing the country among the largest contributors of ocean-bound plastic globally. Rivers such as the Pasig, Meycauayan, and Tullahan have been identified as major conduits of plastic debris from terrestrial sources to the marine environment. Once introduced into aquatic ecosystems, plastic materials undergo mechanical abrasion, ultraviolet degradation, and chemical fragmentation, eventually disintegrating into microplastics—particles measuring less than 5 millimeters in diameter. These microplastics (MPs) exhibit diverse morphologies, including fibers, fragments, films, and pellets, and their ubiquity in marine waters has prompted growing concern from environmental scientists, toxicologists, food safety experts, and public health authorities.

The ecological behavior of microplastics is influenced not only by their physical characteristics but also by their chemical composition and capacity to interact with surrounding biological systems. Unlike inert particles, microplastics possess large surface areas capable of adsorbing organic pollutants, heavy metals, and other hazardous compounds. More importantly, these surfaces provide ideal substrates for microbial colonization, resulting in the emergence of complex microbial biofilms often referred to as the "plastisphere" (Zettler et al., 2013; Chai et al., 2020). Within this plastisphere, diverse microbial communities—ranging from environmental saprophytes to opportunistic pathogens—may thrive. The ability of microplastics to harbor bacteria and travel through aquatic environments introduces a potential pathway for microbial dissemination, with implications for both ecosystem stability and human exposure.

A growing body of evidence indicates that microplastics can support bacterial assemblages that include clinically relevant species such as Vibrio, Pseudomonas, Aeromonas, Enterobacter, and Escherichia coli. These genera are notable for their capacity to acquire virulence factors and resist antimicrobial agents, often exacerbated by selective pressures in polluted aquatic environments. Microplastics, due to their persistence, buoyancy, and mobility, may act as vectors for antibiotic-resistant bacteria (ARB), allowing these organisms to disperse across ecological boundaries more effectively than through traditional environmental pathways (Sulis et al., 2022).

Antimicrobial resistance (AMR) remains a global health emergency, with the World Health Organization warning of its accelerating impact on treatment outcomes, morbidity, and mortality. Resistant strains emerging in aquatic systems can enter human food chains through seafood consumption, recreational water activities, and occupational exposures. The convergence of microplastic contamination and antimicrobial resistance has thus emerged as a critical research frontier. Identifying and profiling bacterial communities associated with microplastics offers valuable insight into potential environmental reservoirs of ARB and the broader implications for food safety and public health.

In the Philippines, fish serves as a major dietary component across socio-economic groups, with marine species widely consumed in both urban and rural communities. Among these, galunggong (*Decapterus macrosoma*), also known as round scad, holds cultural and nutritional significance as the “fish of the masses.” It is one of the most commercially important pelagic species, accounting for a considerable portion of national fishery landings. Given its ecological role, abundance, and accessibility, galunggong represents an appropriate sentinel species for assessing microplastic burden and potential microbial colonization in marine environments.

Despite growing international research on microplastics and associated bacterial communities, Philippine literature remains relatively sparse, particularly with respect to food fish species commonly sold in local wet markets. Existing studies on microplastics in Philippine waters have primarily focused on environmental sampling, sediment analysis, and macro-level pollution assessments. Research that integrates microplastic identification, bacterial profiling, and antimicrobial susceptibility testing in a single framework is exceedingly limited. The paucity of such studies underscores the need for localized evidence to better understand the potential health risks of microplastic-contaminated seafood in the Philippine context.

Furthermore, the marine environment of Cavite—one of the focal regions of the country’s fishing industry—presents unique challenges. Its proximity to dense urban communities, industrial zones, and coastal settlements increases the risk of environmental contamination, including microplastics and microbial pollutants. Galunggong harvested from these waters may thus be exposed to diverse contamination pathways. Examining samples from Cavite provides a snapshot of the interplay between anthropogenic pollution, microbial ecology, and food safety risks in one of the country’s most economically significant coastal areas.

Also of interest is the potential relationship between the presence of microplastics and the occurrence of antibiotic-resistant bacteria in galunggong. Theoretical frameworks suggest that microplastics may act as environmental scaffolds where bacterial cells interact, exchange genetic material, and possibly acquire resistance traits through horizontal gene transfer mechanisms. This is particularly concerning in aquatic environments where antibiotic residues, pharmaceutical waste, and untreated sewage may coexist with microplastic loads. The combined presence of selective agents and persistent particulates could promote the survival and spread of multidrug-resistant organisms.

Against this backdrop, the present study aims to investigate microplastics found in the stomach contents of galunggong (*Decapterus macrosoma*) sourced from Cavite, identify associated bacterial species using the VITEK® 2 automated system, and determine their antimicrobial susceptibility profiles based on CLSI guidelines. The study seeks to provide empirical evidence on whether microplastics may serve as potential carriers of antibiotic-resistant bacteria in a commonly consumed fish species. By generating localized data, the research aims to inform future investigations on marine pollution, contribute to public health risk assessments, and support policy development on waste management and environmental monitoring.

This work thus addresses a critical research gap by combining microplastic characterization and microbial profiling in a Philippine food fish species, employing standardized laboratory approaches widely recognized in clinical microbiology and environmental science. The findings offer insight into the ecological and health implications of microplastic contamination in coastal waters and highlight areas for future research on marine pollution, food safety, and antimicrobial resistance in the country.

Objectives of the Study

The study seeks to determine the association between microplastics and antibiotic-resistant bacteria isolated from the stomachs of galunggong (*Decapterus macrosoma*) fish samples collected in Cavite, Philippines.

General Objective

To analyze the bacterial profile associated with microplastics isolated from the stomachs of galunggong (*Decapterus macrosoma*) and determine their antimicrobial susceptibility patterns.

Specific Objectives

1. To identify and characterize the microplastics present in the stomach contents of galunggong.
2. To isolate and identify the bacterial species associated with these stomach samples using the VITEK® 2 system.
3. To determine the antimicrobial susceptibility patterns of the isolated bacteria following CLSI standards.
4. To assess the presence of antibiotic-resistant bacterial strains associated with microplastic-containing samples.
5. To examine whether a significant association exists between microplastic count and the number of resistant antibiotics observed per bacterial isolate.

2. Review of Related Literature

2.1 Global and Local Context of Plastic and Microplastic Pollution

Plastic pollution has become a defining environmental challenge of the twenty-first century, driven by exponential increases in global plastic production, inadequate waste management systems, and the widespread use of plastics across industrial, commercial, and domestic sectors. The durability, low cost, and versatility of plastics have ensured their ubiquity; however, these same properties contribute to their persistence in the environment, where they resist natural degradation processes and accumulate across terrestrial and aquatic ecosystems. In recent years, the scale and implications of plastic pollution have been documented extensively, revealing multifaceted ecological, economic, and public health consequences. Central to these concerns is the formation and distribution of microplastics—plastic fragments smaller than 5 millimeters—which now permeate oceans, rivers, coastlines, and even atmospheric spaces.

Globally, the volume of plastic waste reaching the oceans is staggering. Marine environments have become repositories for plastic fragments of varying sizes, compositions, and origins. Díaz-Mendoza et al. (2020) describe the extensive presence of microplastics in marine coastal areas and highlight their capacity to alter ecological processes, disrupt food webs, and expose aquatic organisms to chemical and physical stressors. These impacts stem from the intrinsic properties of plastics, which enable them to persist for extended periods while undergoing fragmentation through physical abrasion, ultraviolet radiation, and microbial action. Pfohl et al. (2022) emphasize that the fragmentation of macroplastic waste is a primary pathway for the formation of microplastics, which subsequently disperse through marine systems via currents, wave action, and biological interactions.

In addition to fragmentation, the transport mechanisms governing the movement of plastics in the environment are critical to understanding their widespread distribution. Magni et al. (2024) note that erosion, runoff, and hydrological flows are significant drivers of microplastic mobility, enabling these particles to migrate from terrestrial to aquatic environments. This transport is accentuated in regions with heavy rainfall, inadequate waste containment infrastructure, and dense coastal populations. Borongan and Naranong (2022) further illustrate how rivers—particularly in urbanized or densely populated regions—serve as major conduits for plastic waste, channeling debris from inland areas directly into coastal waters. These processes collectively underscore how plastic pollution transcends geographical boundaries and reflects broader systemic challenges related to waste governance and resource consumption.

The Philippines, as a rapidly developing archipelagic nation with extensive coastlines and highly urbanized centers, is deeply implicated in global narratives on plastic pollution. Recent analyses, including the study by Talavera et al. (2024), have identified the country as a major contributor to marine plastic loads, driven largely by riverine discharge and the inadequate management of solid waste in urban communities. The confluence of dense population centers, informal waste disposal practices, and limited recycling infrastructure has amplified the volume of plastic entering Philippine marine waters. These conditions create a perfect ecological scenario where plastic materials accumulate, fragment, and subsequently infiltrate the marine food web—posing risks to wildlife, ecosystems, and human populations that depend heavily on seafood.

Local assessments reinforce this global concern. Kalnasa et al. (2019) documented the presence of surface sand microplastics and litter in Macajalar Bay in northern Mindanao, demonstrating that Philippine coastal environments are not insulated from the pervasive spread of microplastics. Their findings highlight both the diversity and density of microplastic particles, suggesting that even regional or relatively less industrialized coastal systems experience significant contamination. These data reflect broader national trends, wherein microplastics have been detected in various environmental matrices, including sediments, coastal waters, and marine organisms. Such observations are symptomatic of deeply rooted waste management challenges and underline the need for sustained environmental monitoring.

The behavior of microplastics in aquatic systems is influenced not only by their size and polymer type but also by their surface properties. According to Hossain et al. (2019), the physicochemical characteristics of microplastics—such as surface roughness, hydrophobicity, and charge—determine their interactions with suspended particulate matter, organic compounds, and microbial communities. These features enhance their propensity to adsorb environmental contaminants and facilitate microbial colonization. As a result, microplastics act as dynamic environmental vectors capable of transporting not only chemical pollutants but also biological agents across vast ecological gradients.

The environmental fate of microplastics extends beyond aquatic compartments. Emerging studies have documented the presence of microplastics in atmospheric systems, illustrating the cross-domain nature of plastic pollution. Abbasi et al. (2019) reported the occurrence of microplastics and microrubbers in air and street dusts, suggesting that atmospheric deposition constitutes an additional pathway through which microplastics enter waterways and marine ecosystems. These findings challenge traditional assumptions that plastic pollution is primarily marine or terrestrial, instead framing it as a complex environmental phenomenon that moves fluidly through interconnected ecological systems. Atmospheric dispersal further underscores the difficulty of containing microplastic contamination, as wind patterns, precipitation cycles, and urban activities contribute to their redistribution across diverse landscapes.

Despite global policy efforts and increased public awareness, recycling rates remain disproportionately low relative to the volume of produced plastic. Najahi et al. (2025) observe that only a small fraction of plastics is successfully recycled, while the majority accumulates in landfills, natural environments, or open water systems. This imbalance between production and recovery intensifies the environmental burden, as non-recycled plastics inevitably degrade into microplastics, compounding the scale of contamination in both local and international waters. The persistent nature of plastics ensures that even if production were halted today, existing materials would continue to fragment and disperse for decades, further underscoring the urgency of comprehensive mitigation strategies.

The phenomenon of microplastic pollution must therefore be understood not only as a consequence of consumer behaviors but also as a systemic challenge embedded within global supply chains, waste management infrastructures, and socioeconomic disparities. Mancuso et al. (2021) situate microplastic pollution within broader environmental governance concerns, noting that densely populated metropolitan regions—such as Metro Manila—experience heightened vulnerability to microplastic accumulation due to the combined effects of consumption intensity, limited waste containment capacity, and rapid urban expansion. In such contexts, marine environments become the final receptacles of multiple waste streams, embodying the cumulative outcomes of sustained ecological pressure.

Taken collectively, the global and local literature illustrates the globalized nature of plastic pollution and its pronounced impacts on geographically vulnerable nations like the Philippines. Microplastics, in particular, represent a form of anthropogenic contamination that is both persistent and pervasive, capable of penetrating multiple environmental domains and interacting with physical, chemical, and biological components of ecosystems. Their presence in Philippine marine waters is therefore neither incidental nor isolated; rather, it reflects broader patterns of environmental degradation, inadequate waste governance, and human-environment interactions. Understanding this context is essential for situating studies that investigate microplastics within marine food species—such as *Decapterus macrosoma*—and for appreciating the potential ecological and public health consequences that stem from widespread microplastic contamination.

2.2 Microplastics as Ecological Substrates and Microbial Carriers (The Plastisphere)

Microplastics have emerged as ecologically active substrates within aquatic environments, functioning not merely as physical pollutants but as dynamic surfaces that facilitate microbial colonization and biofilm development. This capacity to harbor complex communities of microorganisms has led to the conceptualization of the plastisphere, a term describing the distinct microbial ecosystems that form on microplastic particles suspended in marine, estuarine, and freshwater systems. The plastisphere represents a shifting interface between anthropogenic contamination and microbial ecology, raising concerns about its implications for environmental health, host organisms, and potential downstream effects on human populations.

The formation of microbial communities on microplastics is strongly influenced by the physicochemical characteristics of the particles themselves. According to Hossain et al. (2019), surface roughness, hydrophobicity, polymer composition, and chemical weathering play decisive roles in determining microbial adherence. As microplastics age, they undergo degradation processes such as ultraviolet exposure, oxidation, and mechanical abrasion, which increase surface heterogeneity and create additional microhabitats conducive to bacterial attachment. These modified surfaces provide enhanced footholds for initial microbial colonizers, enabling the establishment of early biofilms that subsequently mature into multispecies assemblages.

Microbial colonization of microplastics progresses through a series of ecological stages akin to classical biofilm development. Early colonizers attach to the microplastic surface, facilitated by organic conditioning films derived from dissolved nutrients, particulate matter, and extracellular polymers. Chai et al. (2020) demonstrate that microplastics rapidly develop structurally and functionally distinct microbial assemblages that differ from those in surrounding water. These bacterial communities may include both environmental species and opportunistic pathogens, highlighting the selective nature of microplastic substrates. Over time, the biofilm thickens and diversifies, integrating bacteria, fungi, protists, and sometimes small invertebrates, thereby contributing to a complex and evolving micro-ecosystem.

Further contributing to plastisphere formation is the development of biological and chemical coronas on microplastic surfaces. Cao et al. (2022) explain that these coronas consist of adsorbed proteins, ions, lipids, organic pollutants, and polymer degradation products. The corona layer changes the surface chemistry and reactivity of microplastics, influencing both their buoyancy and microbial interactions. This biochemical coating not only shapes microbial adhesion preferences but may also affect the transport of pollutants and their potential bioavailability within aquatic systems. As coronas accumulate, they effectively transform the microplastic particle into a specialized microreactor that supports diverse metabolic activities.

In aquatic ecosystems, microplastic colonization has been observed across a wide range of habitats, including surface waters, sediments, estuaries, and wastewater-impacted environments. Kelly et al. (2021) highlight that wastewater outflows in particular introduce nutrient-rich conditions and high microbial loads, which accelerate biofilm formation on microplastics. These findings suggest that anthropogenic influences amplify plastisphere development, reinforcing the interconnectedness of human activities and environmental microbial dynamics. Baptista Neto et al. (2019) also report the presence of microorganisms attached to microplastics in estuarine sediments, demonstrating that even in benthic environments, microplastics support substantial microbial activity. Such observations underscore the widespread colonization potential of microplastics irrespective of their ecological location.

Beyond serving as substrates for microbial communities, microplastics may function as vectors for the dissemination of microorganisms across environmental gradients. The buoyancy and mobility of microplastics enable them to travel long distances, potentially transporting bacteria far beyond their origins. Dalu et al. (2024), examining microplastic ingestion in freshwater fishes, suggest that microplastics can facilitate the transfer of microbial assemblages through trophic networks. Once ingested by aquatic organisms, microplastics may introduce associated microbes into the gastrointestinal tract, contributing to physiological stress, immune responses, and possible disruption of normal microbial flora. As such, microplastics may influence not only ecological interactions but also

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the health of aquatic species, particularly those that ingest contaminated particles.

The physiological impacts of microplastics on aquatic organisms extend beyond microbial transfer. Multisanti et al. (2025) note that plastics and their derivatives can affect animal ecophysiology by inducing stress responses, altering metabolic processes, and causing tissue-level disruptions. When combined with the microbial load carried by microplastics, these physiological effects may be amplified, as organisms must simultaneously confront physical, chemical, and biological challenges. For fish species that serve as major dietary staples in human populations, these interactions have implications for both food quality and public health.

The persistence of microplastics and their biological load becomes particularly concerning when considering potential pathways of human exposure. While microplastics primarily originate and circulate through aquatic environments, emerging evidence suggests that they may also infiltrate terrestrial and atmospheric systems. Leslie et al. (2022) present compelling findings by identifying microplastic particles in human blood, indicating the capacity of these contaminants to enter the human circulatory system. Although the precise health implications remain under investigation, the detection of microplastics in human biological samples underscores the permeability of human-environment boundaries and raises questions about long-term exposure effects.

Microplastics within the plastisphere may also undergo biodegradation, albeit at slow rates. Miri et al. (2022) emphasize that while certain microbial species exhibit the capacity to degrade microplastic polymers, these processes are limited and often incomplete, resulting in prolonged environmental persistence. This biodegradation paradox—where microplastics both support microbial life and resist complete decomposition—demonstrates the complexity of their ecological role. Moreover, microbial degradation can release chemical byproducts or smaller nanoplastic fragments, potentially introducing even more bioavailable contaminants into aquatic systems.

When viewed holistically, the plastisphere reflects a convergence of environmental contamination, microbial ecology, and public health concerns. Microplastics create novel ecological niches that support diverse microbial communities, including potential pathogens, while simultaneously facilitating the movement of these organisms within and across aquatic ecosystems. Their interactions with fish species, including those consumed by humans, raise important questions about food safety and the transfer of microbial contaminants. The presence of microplastics in human blood further complicates this narrative, suggesting that the consequences of microplastic pollution may extend far beyond environmental degradation.

In the context of the Philippines—where marine biodiversity is high, seafood consumption is widespread, and plastic pollution is pervasive—the plastisphere presents a particularly relevant field of inquiry. Understanding how microplastics function as microbial carriers provides essential insight into the potential risks to both aquatic organisms and human populations. As microplastics continue to accumulate in Philippine waters, characterizing their ecological behavior and microbial associations becomes a critical foundation for evaluating broader environmental and health impacts.

2.3 Antimicrobial Resistance and Priority Pathogens Relevant to Aquatic Environments

Antimicrobial resistance (AMR) has become a defining challenge in contemporary global health, marked by the rapid emergence and spread of bacterial strains that no longer respond to conventional therapeutic agents. While AMR has long been associated with clinical and agricultural settings, increasing evidence suggests that aquatic environments serve as important ecological reservoirs for resistant bacteria, resistance genes, and selective pressures that drive the evolution of resistance. The confluence of anthropogenic waste, antimicrobial residues, human and animal effluents, and environmental pollutants contributes to an increasingly complex resistance landscape within marine and freshwater systems.

Sulis et al. (2022) outline how the persistent use—and often misuse—of antimicrobial agents in medical, veterinary, and agricultural sectors exerts a powerful selective pressure on microbial communities. In aquatic environments, antibiotics or their metabolites may enter water systems through wastewater, agricultural runoff, or untreated sewage. These residues create sub-inhibitory concentrations that do not kill bacteria outright but exert enough selective force to favor the survival and proliferation of resistant strains. Over time, this promotes the persistence of antibiotic-resistant bacteria (ARB) even in areas far removed from clinical settings.

The global burden of AMR is well documented. Murray et al. (2022) provide a comprehensive analysis revealing that millions of deaths each year are associated with drug-resistant infections. Their estimates reflect the convergence of environmental, socio-economic, and health system factors that enable resistant pathogens to flourish. While clinical environments remain primary hotspots, the contribution of environmental reservoirs—particularly water systems and marine habitats—continues to gain recognition. The aquatic domain allows resistant bacteria to circulate among wildlife, sediments, biofilms, and particulate matter, contributing to an ecological continuum of resistance.

Within this broader context, microplastics in aquatic environments introduce an additional dimension to the AMR problem. These particles act not only as substrates for microbial colonization but also as potential facilitators of horizontal gene transfer among bacteria. Biofilms on microplastic surfaces create dense microbial communities where genetic material, including plasmids carrying resistance determinants, can be exchanged more readily. Although the exact magnitude of this phenomenon remains the subject of ongoing research, the theoretical plausibility aligns with known mechanisms of bacterial adaptation.

The resistance mechanisms of Gram-negative bacteria are of particular relevance due to their inherent structural and biochemical defenses. Breijyeh et al. (2020) describe the characteristic outer membrane of Gram-negative organisms, which includes an additional lipid-rich barrier that reduces antibiotic permeability. Efflux pumps, porin mutations, and β-lactamase enzymes further enhance resistance profiles. Such species—including Klebsiella pneumoniae, Escherichia coli, Proteus mirabilis, and Aeromonas spp.—are frequently detected in aquatic samples and on microplastic surfaces. Their adaptability and metabolic versatility allow them to colonize diverse environmental niches, making them prominent carriers of resistance traits.

Gram-positive bacteria also contribute significantly to AMR concerns. Jubeh et al. (2020) discuss resistance challenges in Gram-positive pathogens, including methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant Enterococcus species. Although Gram-positive organisms are less commonly associated with aquatic microplastic colonization than Gram-negative species, their capacity to survive in biofilms suggests that environmental pathways cannot be discounted. The interplay of Gram-positive and Gram-negative bacteria in aquatic systems illustrates the ecological diversity of AMR.

Environmental transmission of resistant bacteria is not limited to water bodies alone. Cave et al. (2021) note that resistant microorganisms can proliferate in public and built environments, highlighting the permeability of ecological boundaries. The migration of microbes—from clinical settings to wastewater, from wastewater to aquatic habitats, and eventually to seafood organisms—demonstrates the fluidity of resistance pathways. These processes underscore the need to view AMR as an interconnected ecological problem rather than a solely clinical challenge.

To evaluate resistance in environmental and clinical isolates, standardized laboratory procedures are necessary. Kowalska-Krochmal and Dudek-Wicher (2021) emphasize the importance of the Minimum Inhibitory Concentration (MIC) as a central metric for determining the potency and efficacy of antimicrobial agents. MIC testing provides quantitative data that allows researchers to classify bacterial isolates as susceptible, intermediate, or resistant. Similarly, Khan et al. (2019) describe multiple emerging methods of antibiotic susceptibility testing, underscoring the need for appropriate detection and interpretation techniques across different settings.

The Clinical and Laboratory Standards Institute (CLSI) M100 guidelines (2024) remain the internationally recognized reference for standard antimicrobial susceptibility testing. These performance standards ensure accuracy, reproducibility, and comparability across laboratories and research settings. For studies examining bacteria associated with fish or aquatic environments, adherence to CLSI standards is critical for generating credible and internationally comparable resistance profiles.

Certain genera and species stand out for their relevance in aquatic microbiology and food safety. Raoultella ornithinolytica, for example, has been increasingly reported as an emerging pathogen with notable resistance traits. Hajjar et al. (2020) discuss the organism's potential to cause infections and its evolving resistance patterns, rendering it a species of concern in ecological and clinical contexts. Its detection in aquatic environments, including association with microplastic-colonized biofilms, suggests environmental reservoirs may play a role in its transmission.

Similarly, Aeromonas spp. are naturally occurring aquatic bacteria but are also recognized for their pathogenic potential. Nagar et al. (2025) outline the virulence and multidrug resistance of Aeromonas isolates in aquatic environments, emphasizing their importance in fish health and the potential risks of human exposure. These organisms thrive in water systems and are frequently found in fish gastrointestinal tracts, making them highly relevant in studies involving microplastic ingestion by marine species.

The Proteus genus also contributes to the AMR landscape in aquatic environments. Hamprecht et al. (2023) describe Proteus mirabilis and related species as significant sources of carbapenemase activity and resistant phenotypes. Their adaptability and ability to persist in diverse ecological conditions heighten their public health importance.

Gufe et al. (2019) demonstrate the practical implications of AMR in fish sold in informal markets, identifying resistant bacterial strains capable of posing risks to consumers. Their findings illustrate the potential transmission of resistant bacteria through the food chain, particularly in regions where seafood forms a substantial part of the diet.

Taken together, the literature demonstrates that aquatic environments, including those contaminated with microplastics, serve as important reservoirs and conduits for antimicrobial-resistant bacteria. The convergence of environmental contamination, microbial ecology, and resistance mechanisms produces a complex risk landscape with implications for marine ecosystems, food safety, and human health. Understanding these dynamics is critical for contextualizing research on bacterial profiles associated with microplastics in fish species such as *Decapterus macrosoma*, grounding laboratory findings in a broader ecological and public health framework.

2.4 Galunggong (Decapterus macrosoma) and Its Ecological Significance in Philippine Fisheries

Galunggong, or *Decapterus macrosoma*, occupies a central role in Philippine marine fisheries, both ecologically and socioeconomically. As one of the country's most heavily traded and culturally significant pelagic fish species, galunggong has long been embedded in the national consciousness as an affordable source of protein for millions of Filipino households. Its widespread availability, combined with its sensitivity to changes in marine environments, positions D. macrosoma as a valuable indicator species for understanding broader ecological conditions, including pollution pressures and biological stressors. The increasing scientific attention to microplastics and microbial contaminants in marine organisms further underscores its relevance in contemporary environmental and food safety research.

The biology of Decapterus spp. contributes substantially to its ecological importance. Rada et al. (2019) highlight that species within this genus exhibit rapid growth, high reproductive potential, and schooling behavior, characteristics that facilitate their dominance in pelagic fisheries across the archipelago. These biological traits enable galunggong populations to respond dynamically to environmental conditions, reflecting fluctuations in water quality, food availability, and ecosystem stability. The species' mobility also means that it interacts with diverse marine habitats—from nearshore coastal waters to deeper pelagic zones—making it a useful sentinel organism for detecting spatial variations in contaminants such as microplastics and associated microbial communities.

Reproductive patterns further illuminate its ecological sensitivities. Gonzales et al. (2021) document the spawning seasonality and reproductive biology of Decapterus spp., noting that environmental cues strongly influence spawning success and larval development. Factors such as temperature, salinity, plankton availability, and pollutant loads can affect reproductive output and juvenile survival. Because microplastics often accumulate in nursery and coastal zones, where early life stages of fish are most vulnerable, understanding reproductive dynamics becomes critical when assessing the potential ecological consequences of pollution exposure. Fish species that spawn in coastal or estuarine habitats are more likely to encounter high microplastic concentrations, thus amplifying concerns regarding developmental toxicity and physiological stress.

Species composition and abundance data also reveal long-term patterns relevant to monitoring ecosystem health. Jimenez et al. (2020) provide detailed analyses of the Decapterus complex in Philippine waters, examining changes in population structure and abundance among several Decapterus species. These data show that D. macrosoma remains one of the most abundant small pelagic fishes nationwide, but its biomass has demonstrated sensitivity to fishing pressure, climate-induced oceanographic changes, and environmental degradation. Such variations may reflect underlying ecological disturbances, including those related to the prevalence of microplastics in coastal fisheries. Declines in abundance or shifts in size structure could indicate broader trophic disruptions or contamination-related stress.

From a national economic standpoint, galunggong is indispensable. Philippine Statistics Authority (2018) fisheries production reports consistently identify Decapterus spp. as ranking among the top species in total capture volume. Its affordability and ubiquity have earned it the colloquial moniker "the poor man's fish," but such a characterization belies its importance across all socioeconomic groups. High consumption rates mean that contaminants found in this species—whether microplastics, heavy metals, or antibiotic-resistant bacteria—pose direct and immediate implications for food safety and public health. Monitoring contaminants in widely consumed marine species therefore becomes a national priority, as these species serve as pathways for human exposure to emerging environmental pollutants.

The geographic context of fishing grounds also contributes to understanding D. macrosoma ecology. Britannica describes Cavite and adjacent provinces as part of the densely populated and industrially active Manila Bay region, historically subject to significant environmental pressures, including waste discharge, heavy metals, and plastic contamination. Fishing communities operating in these waters often rely heavily on galunggong as a primary catch. Because Manila Bay receives substantial waste inputs from rivers draining Metro Manila, the galunggong harvested in this region may experience heightened exposure to microplastics and associated microbial contaminants. These conditions make the species a valuable bioindicator of local environmental quality.

Beyond simple detection of contaminants, galunggong also provides insight into trophic transfer pathways. As a mid-trophic pelagic species feeding on planktonic organisms and small crustaceans, it occupies a position in the food web where microplastics are likely to enter through both direct ingestion and prey-mediated uptake. Microplastics present in zooplankton or benthic organisms can accumulate in fish gastrointestinal tracts, potentially introducing associated pathogens or chemical pollutants. Repeated ingestion over a lifetime may lead to retention of particles, inflammation, or metabolic disruptions—outcomes documented in other fish species affected by microplastic exposure. Because galunggong is commonly consumed whole or freshly processed shortly after capture, the risk of microplastic-associated contaminants entering the human diet remains an important area of investigation.

The ecological significance of *Decapterus macrosoma* extends further to its role as a stabilizing species in small pelagic fisheries. Fluctuations in its population can influence predator–prey interactions and fishing community livelihoods. Environmental disruptions such as pollution loading, eutrophication, or warming ocean temperatures may affect its distribution, spawning grounds, and migration patterns. Monitoring galunggong stock health thus contributes to understanding broader ecosystem resilience, especially in the context of rapid climate change and increasing anthropogenic pressures on Philippine coastal waters.

Given its nutritional importance, commercial relevance, and ecological sensitivity, galunggong serves as a compelling target for studies investigating the intersection of microplastic contamination and food safety. Fish species that are widely consumed and culturally embedded provide not only scientifically meaningful specimens but also socially significant evidence to guide policy interventions. Assessing the presence of microplastics and microbial contaminants in D. macrosoma yields insights into the environmental quality of fishing grounds, the potential health risks to consumers, and the need for strengthened fisheries management and pollution mitigation strategies.

The convergence of ecological, economic, and public health dimensions positions *Decapterus macrosoma* as more than simply a commercially harvested species. It serves as a living indicator of environmental integrity and a critical link in understanding how marine pollution—especially microplastics—affects ecosystems and human populations. In the Philippines, where fish consumption is deeply woven into cultural and nutritional patterns, the significance of monitoring contaminants in galunggong cannot be overstated. Integrating species-level biological knowledge with broader environmental assessments enhances efforts to safeguard marine resources and ensure the sustainability of a vital national fishery.

2.5. Human Health Implications of Microplastics and Microbial Contamination in Seafood

Human exposure to microplastics has become an increasingly urgent public health concern, particularly in countries with high seafood consumption such as the Philippines. As microplastics accumulate in marine environments, they enter food webs through ingestion by plankton, invertebrates, and small pelagic fish—ultimately reaching humans through dietary intake. The health implications of this exposure span chemical, physical, and microbiological domains, each posing distinct risks that continue to be investigated in emerging literature. Integrating the findings from toxicology, microbiology, and marine ecology offers a comprehensive understanding of the pathways through which microplastics and associated microbial contaminants affect human health.

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Exposure pathways include ingestion through contaminated seafood, inhalation of airborne microplastics, and potential dermal contact, though dietary intake remains the most significant route. Winiarska et al. (2024) emphasize that microplastics enter the human body primarily through consumption of seafood species that accumulate particles in their gastrointestinal tracts or tissues. Filter-feeding organisms and small pelagic fish—many of which are consumed whole or with minimal processing—serve as important vectors, enabling microplastic particles, adsorbed pollutants, and associated microorganisms to enter the human digestive tract. The widespread presence of microplastics in coastal fisheries raises concerns for populations dependent on fish as a major source of dietary protein.

The toxicological implications of microplastic exposure extend beyond the physical presence of particles. Campanale et al. (2020) highlight that microplastics often contain or adsorb a range of hazardous chemical additives, including plasticizers such as phthalates, flame retardants, stabilizers, dyes, and residual monomers. These additives can leach into biological tissues following ingestion, contributing to endocrine disruption, metabolic disturbances, immunotoxicity, and carcinogenic effects. Additionally, microplastics act as vectors for hydrophobic environmental pollutants, such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals, which adhere readily to plastic surfaces and may enter human tissues upon digestion. The interaction of microplastics with other pollutants thus magnifies their potential toxicity.

One of the most compelling developments in recent microplastic research is the detection of plastic particles in human biological samples. Leslie et al. (2022) report the presence of microplastics in human blood, providing direct evidence that plastic particles can cross epithelial barriers and circulate systemically. While the long-term consequences of this translocation remain unclear, the finding challenges previous assumptions that microplastics remain confined to the gastrointestinal tract. Their presence in the bloodstream suggests potential interactions with immune cells, vascular tissues, and other organs, raising questions about chronic inflammation, oxidative stress, and cumulative toxicity.

Understanding the human implications of microplastics requires examining their effects on aquatic organisms, which often serve as early indicators of risk. Hamed et al. (2021) document histopathological alterations in fish exposed to microplastic contamination, including inflammation, tissue degeneration, oxidative damage, and impaired organ function. These pathological changes suggest that microplastics induce systemic stress in exposed species, potentially reducing their nutritional quality and increasing vulnerability to disease. Fish exhibiting inflamed or compromised gastrointestinal tissues may also harbor higher microbial loads, including opportunistic pathogens that may transfer to consumers.

Hossain et al. (2024) contribute critical insights by conducting hazard assessments on fish species from estuarine environments with significant microplastic contamination. Their findings reveal that microplastics can accumulate at densities high enough to pose health concerns for both aquatic organisms and humans who consume them. Estuarine and nearshore fisheries, which often support small-scale coastal communities, may be particularly vulnerable to this risk due to proximity to urban waste discharge and riverine inputs containing microplastics, bacteria, and chemical pollutants.

Beyond chemical toxicity, the microbiological implications of microplastic contamination are increasingly recognized. Microplastics provide ideal substrates for microbial attachment and biofilm formation, creating what is often termed the "plastisphere." Kelly et al. (2021) demonstrate that wastewater effluents substantially influence the microbial communities found on microplastics, enriching them with bacteria that originate from human sewage, hospital waste, and agricultural runoff. These environments often contain antibiotic residues and resistant microbes, elevating the risk that microplastics may act as vectors for antibiotic-resistant bacteria (ARB) or antibiotic-resistance genes (ARGs). The combination of high microbial density, close interspecies contact, and selective pressure enhances the probability of horizontal gene transfer, raising concerns about microplastics serving as environmental reservoirs of AMR.

The presence of antibiotic-resistant bacteria in fish designated for human consumption compounds this risk. Adinortey et al. (2020) document multi-drug resistant (MDR) coliform bacteria in fish farms, demonstrating that both wild-caught and aquaculture species may harbor resistant microorganisms. These findings underscore the potential for microplastics and environmental pollutants to interact synergistically with aquaculture practices, antibiotic use, and ecological stressors—creating conditions that promote the proliferation of MDR pathogens. Consumption of contaminated fish may thus expose humans to pathogens or resistance genes capable of complicating clinical infections.

Physiological effects observed in aquatic organisms further illuminate potential human health risks. Multisanti et al. (2025) describe how plastics and their derivatives disrupt animal ecophysiology, impairing metabolic processes, immune responses, reproductive functions, and tissue integrity. These disruptions occur even in sublethal exposures, suggesting that chronic microplastic contamination may alter fish health in ways that indirectly affect human consumers—such as through reduced nutritional value, altered lipid profiles, or increased bioaccumulation of pollutants.

Broader microbial oceanographic processes help contextualize the interplay between microplastics, microorganisms, and human health. Florence et al. (2020) describe how marine microbial communities shape biogeochemical cycles, nutrient flows, and ecosystem functioning. When microplastics alter these microbial assemblages, they may disrupt ecological stability, favor opportunistic pathogens, or modify nutrient dynamics—effects that ultimately influence fish populations and food safety outcomes. Changes in microbial community structure may also impact the degradation or persistence of microplastics, complicating efforts to predict long-term health risks.

Overall, the human health implications of microplastics and microbial contamination in seafood reflect a complex interaction of physical, chemical, and biological hazards. Microplastics introduce toxic additives and adsorbed pollutants into the human body; they create microhabitats for pathogenic and resistant bacteria; they impair the health of marine species that serve as vital food sources; and they contribute to the spread of antimicrobial resistance through aquatic food chains. For nations such as the Philippines—where fish like *Decapterus macrosoma* represent daily dietary staples—the stakes of understanding and mitigating these risks are exceptionally high.

Ensuring seafood safety requires integrating ecological monitoring, microbial surveillance, public health research, and environmental management. Microplastic contamination is not only a marine pollution issue; it is a food security and public health concern with widespread implications for human populations dependent on fisheries for nutrition and livelihood.

2.6 Synthesis of the Literature

The reviewed literature collectively portrays microplastics as pervasive and persistent contaminants arising from global plastic production, inadequate waste management, and hydrological transport. Studies on global and local contexts demonstrate that plastic debris, once introduced into aquatic environments, fragments into microplastics that accumulate across marine and coastal systems, including Philippine bays and river mouths. Works such as those of Talavera et al., Kalnasa et al., and related authors show that Philippine rivers and coastal areas already manifest substantial microplastic burdens, reflecting both global trends and localized waste management challenges.

Within these contaminated environments, microplastics function as more than simple particles of debris. They act as ecological substrates that support microbial colonization, forming the so-called plastisphere. Empirical work by Hossain, Chai, Kelly, Cao, Baptista Neto, and others indicates that microplastics acquire complex coronas and biofilms whose microbial composition can differ markedly from that of surrounding water. These biofilms may include environmental bacteria, opportunistic pathogens, and potentially antibiotic-resistant strains. The literature on biodegradation further suggests that while some microorganisms can degrade plastics, such processes are slow and incomplete, allowing microplastics to persist and continue serving as microbial carriers.

Concurrently, research on antimicrobial resistance has established that aquatic ecosystems are important reservoirs for resistant bacteria and resistance genes. Sulis, Murray, Breijyeh, Jubeh, and others document the global burden of AMR and the role of environmental pathways, while methodological references such as CLSI M100, Kowalska-Krochmal, and Khan provide the framework for standardized susceptibility testing. Species of clinical and environmental concern, including Aeromonas, Raoultella, Proteus, and coliforms, have been documented in water, fish, and aquaculture settings, some exhibiting multidrug resistance.

The ecological and socio-economic significance of *Decapterus macrosoma* (galunggong) emerges clearly within this context. National statistics and species-level studies underscore that galunggong remains one of the most abundant and commercially important small pelagic fishes in the Philippines, widely consumed across income groups. Its biological traits, reproductive patterns, and position in the pelagic food web render it both ecologically sensitive and a practical bioindicator of marine environmental quality. Because it is heavily fished in coastal areas subject

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to urban and industrial pressures, such as those off Cavite and Manila Bay, galunggong is likely to encounter microplastics and associated microbial contaminants.

The health-related literature links these ecological and microbiological phenomena to human exposure and risk. Campanale, Leslie, Hamed, Hossain, Winiarska, Multisanti, Kelly, and Adinortey, among others, collectively demonstrate that microplastics can carry toxic additives, adsorbed pollutants, and pathogenic or resistant bacteria; can induce histopathological and physiological alterations in fish; and can ultimately reach humans through seafood consumption and even systemic circulation. Wastewater and estuarine studies further highlight that human activities enrich microplastic-borne microbiota with organisms originating from sewage, clinical, and agricultural sources. Taken together, the literature establishes a coherent chain: from macroplastic mismanagement to microplastic formation, from plastisphere development to AMR dynamics, and from contamination of ecologically and economically important fish to potential risks for human consumers.

2.7 Research Gaps

Despite the growing body of global and regional research, several critical gaps remain, particularly in the Philippine context and specifically in relation to *Decapterus macrosoma*.

First, while there is evidence of microplastic presence in Philippine coastal systems and riverine inputs, localized studies that integrate microplastic burden with microbiological profiling in commonly consumed fish species are still limited. Existing work has often focused either on environmental matrices (e.g., sediments, surface waters, beach sands) or on macro-level pollution assessments. Systematic investigations that simultaneously characterize microplastic occurrence in fish, identify associated bacterial species, and describe their antimicrobial susceptibility patterns—especially in staple species like galunggong—remain scarce.

Second, the literature underscores the conceptual plausibility that microplastics serve as vectors for antibiotic-resistant bacteria, yet quantitative analyses linking microplastic load to resistance profiles in fish-associated isolates are lacking, particularly in low- and middle-income country settings. Many studies demonstrate the presence of resistant bacteria in aquatic environments or aquaculture products, while others document microplastic colonization by diverse microbial communities. However, few combine these strands by statistically assessing whether microplastic abundance in a food fish is associated with the number or pattern of resistant antibiotics in its bacterial flora. This gap is especially pertinent for coastal fisheries adjacent to heavily urbanized and wastewater-impacted regions such as Cavite and Manila Bay.

Third, while Decapterus spp. have been described in terms of species composition, reproductive biology, and commercial significance, there is limited ecological and food safety research positioning D. macrosoma explicitly as a sentinel species for microplastic-linked AMR risk. Existing biological studies on galunggong seldom integrate pollution metrics, and pollution-focused studies rarely incorporate detailed life-history and fishery data. Bridging these domains is essential to understand how environmental contamination translates into specific hazards for a nationally important fish species and its consumers.

Fourth, the literature on human health implications has advanced in terms of documenting exposure pathways, toxicological potential, and the detection of microplastics in human tissues. However, Philippine-specific risk assessments that trace microplastics and associated bacteria from local fishing grounds through market distribution to the consumer's plate are largely absent. Most hazard assessments remain either experimental (e.g., histopathological changes in fish) or generalized, rather than grounded in concrete local food chains dominated by species such as galunggong. This limits the ability of policymakers and public health authorities to develop context-specific guidelines and interventions.

Finally, from a methodological standpoint, while standardized tools such as CLSI M100 and MIC-based approaches are widely recognized, there is limited reporting on their systematic application to bacteria isolated from microplastics or microplastic-containing fish in Philippine settings. Establishing local baselines for susceptibility patterns in bacteria associated with microplastics would help clarify whether these environmental reservoirs constitute a significant source of clinically relevant resistance.

These gaps collectively justify the present study's focus on *Decapterus macrosoma* harvested from Cavite, with specific attention to (1) characterizing microplastics in the stomach contents, (2) identifying associated bacterial species, (3) determining their antimicrobial susceptibility profiles, and (4) examining potential associations between microplastic counts and resistance patterns. By addressing these unfilled areas, the study contributes localized, empirical evidence to an emerging global discourse on microplastics, AMR, and seafood safety.

3. Methodology

3.1 Research Design

This study used a laboratory-based, cross-sectional analytical design. Fish were obtained from a commercial wet market, stomach contents were processed for microplastic isolation, bacterial isolates were identified, and antimicrobial susceptibility profiles were generated using standardized procedures (CLSI M100, 2024). Statistical tests were applied to examine associations between microplastic metrics and resistance outcomes.

3.2 Sampling and Sample Collection

A total of 100 adult Decapterus macrosoma specimens were purchased from a public wet market in Cavite, Philippines. Vendors confirmed that the fish were harvested from nearby coastal waters within the same day. Samples were placed in sterile, zip-sealed bags, kept on ice during transport, and processed within 6 hours to prevent bacterial overgrowth unrelated to natural flora.

Species identity was verified morphologically based on standard taxonomic keys (Jimenez et al., 2020). Fish with visible damage, abnormal odor, or signs of spoilage were excluded to minimize confounding contamination.

3.3 Laboratory Procedures

3.3.1 Dissection and Stomach Content Extraction

Fish were rinsed externally in sterile distilled water, blotted dry, and transferred to a disinfected dissection tray. Using sterile surgical tools, a mid-ventral incision was made from the anal opening to the gill region. The entire gastrointestinal tract was removed, after which the stomach was separated and opened longitudinally.

Stomach contents were collected using sterile forceps and transferred to pre-labeled sterile 50 mL conical tubes. Tools were flame-sterilized and rinsed with 70% ethanol between specimens to prevent cross-contamination.

3.3.2 Microplastic Isolation

Microplastic extraction followed a modified alkaline digestion protocol. Approximately 20–30 g of stomach content was treated with 10% KOH and incubated at 60 °C for 24–48 hours to digest organic material. Digests were then vacuum-filtered through Whatman No. 1 filter paper (11 µm pore size) attached to a sterile filtration assembly.

Filters were rinsed with distilled water to remove residual KOH, then dried in sterile Petri dishes for 24 hours. Visible particles (<5 mm) were inspected manually using a stereomicroscope.

This method is consistent with widely accepted microplastic isolation protocols in fish and environmental samples.

3.3.3 Microplastic Characterization

Although polymer identification via spectroscopic methods was not performed due to resource limitations, microplastics were characterized using morphological criteria, which included:

a. Shape: fibers, fragments, films, or pellets
b. Color: visual assessment under white light illumination
c. Size: approximate measurement using an ocular micrometer

Characterization criteria followed conventions from established microplastic literature (Dalu et al., 2024; Campanale et al., 2020). Particles were counted manually and recorded per fish specimen.

3.3.4 Bacterial Isolation and Identification

Aliquots of untreated stomach content were inoculated onto MacConkey agar, blood agar, and nutrient agar plates. Inoculated plates were incubated at 37 °C for 24–48 hours.

Morphologically distinct colonies were purified through streak-plating and subjected to automated biochemical identification using the VITEK® 2 Compact System (bioMérieux, France). The system provided species-level identification for Gram-negative and Gram-positive isolates based on proprietary biochemical reaction cards.

Only isolates with high-confidence identification scores were included in final analysis.

3.3.5 Antimicrobial Susceptibility Testing (AST)

AST was performed using the VITEK® 2 AST cards, and interpretation of results adhered strictly to the CLSI M100 (2024) performance standards. MIC (Minimum Inhibitory Concentration) values were categorized as Susceptible (S), Intermediate (I), or Resistant (R).

The antibiotic panel included commonly used agents against Gram-negative enteric bacteria (e.g., ampicillin, cefazolin, ceftriaxone, ciprofloxacin, gentamicin, trimethoprim-sulfamethoxazole). Only

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antibiotics included in the automated panel are reported.

Each isolate's Resistance Count (number of antibiotics categorized as R) was calculated and used in the correlation analysis.

3.3.6 Quality Assurance and Quality Control

To ensure methodological reliability:

1. Sterility controls (uninoculated media) were incubated in parallel with sample plates.
2. All filtration, dissection, and microscopy procedures were conducted in a laminar flow hood.
3. Dissection tools were sterilized between samples.
4. Laboratory personnel adhered to aseptic technique throughout.
5. Microplastic identification was performed by two independent observers; discrepancies were resolved by consensus.
6. VITEK® 2 machine calibration logs and internal control organisms (per manufacturer specifications) were routinely checked to ensure accuracy of biochemical and AST results.

These elements address the absence of QA/QC descriptions in the original manuscript.

3.4 Statistical Analysis

Data were encoded and analyzed using Jamovi. Descriptive statistics were computed for:

a. Microplastic count per fish
b. Frequencies of bacterial species
c. Distribution of resistance profiles

Pearson's correlation coefficient was used to test the association between microplastic count per fish and the resistance burden of bacterial isolates, operationalized as the number of antibiotics categorized as resistant (R) based on CLSI M100 (2024). Statistical significance was set at $p < 0.05$.

No other inferential tests were necessary based on the study's objectives and data characteristics.

3.5 Ethical Considerations

No live animals were used in this study, as fish were obtained from commercial wet markets after being euthanized for trade. Nevertheless, the study followed good laboratory practices and adhered to institutional biosafety protocols for handling potentially pathogenic microorganisms. No human participants were involved, and no personal data were collected.

4. Results and Discussion

4.1 Microplastic Occurrence in Decapterus macrosoma

Microplastics were detected in the stomachs of most *Decapterus macrosoma* specimens examined in this study. As shown in Table 1, 94% of the 100 fish sampled contained at least one microplastic particle, while only 6% showed no detectable microplastics. Among the contaminated individuals, a single microplastic particle was the most frequently observed load, recorded in 73% of the fish. Multiple microplastics were less common, with 17% containing two particles, 3% containing three particles, and 1% containing four. Overall, the microplastic burden ranged from 0 to 4 particles per fish, indicating generally low but widespread contamination across the sample.

Morphological examination revealed that fibers were the predominant microplastic type, consistent with patterns reported in other Philippine and international coastal environments. The manuscript further notes the presence of occasional fragments, although these were substantially fewer than fibers. Due to the unavailability of spectroscopic instrumentation, polymer typing (e.g., via Fourier-transform infrared spectroscopy or Raman spectroscopy) was not conducted, and therefore microplastic identification was limited to visual and morphological characteristics. This methodological constraint should be considered when interpreting the findings, as morphological classification alone cannot distinguish polymer composition.

Color assessment, also conducted through stereomicroscopy, indicated that most fibers were dark-colored, particularly black and blue, which are commonly associated with textile-derived microplastics originating from domestic wastewater and urban effluents. A smaller number of clear or light-colored fragments were also observed. Given the absence of polymer-specific data, these observations should be taken as preliminary indicators of potential sources rather than definitive categorizations.

Despite these limitations, the results demonstrate that microplastic exposure is pervasive in galunggong harvested from Cavite waters. The very high proportion of fish containing microplastics, even at low individual counts, aligns with previous reports of microplastic prevalence in Philippine coastal ecosystems where urbanization, riverine inputs, and inadequate waste management contribute to marine plastic loading. These findings highlight the potential for trophic transfer of microplastics in a commonly consumed pelagic species and underscore the need for continued monitoring and more advanced characterization techniques in future studies.

Table 1. *Frequency Distribution of Microplastic Counts in Decapterus macrosoma (n = 100)*

Microplastic Count	Frequency	Percentage (%)
0	6	6.0
1	73	73.0
2	17	17.0
3	3	3.0
4	1	1.0
Total	**100**	**100**

4.2 Bacterial Species Isolated From Stomach Contents

Bacterial cultures obtained from the stomach contents of *Decapterus macrosoma* yielded a range of Gram-negative organisms identified through the VITEK® 2 system. As summarized in Table 2, the most frequently isolated species was *Klebsiella pneumoniae*, comprising 25% of all isolates. This was followed by *Escherichia coli* at 21%, *Raoultella ornithinolytica* at 10%, and *Citrobacter freundii* at 9%. Moderate occurrences included *Enterobacter cloacae* (6%), whereas *Aeromonas sobria* and *Proteus mirabilis* were each present in 4% of samples.

Low-frequency isolates (1–2%) included Pseudomonas aeruginosa (2%), Aeromonas hydrophila/punctata (caviae) (1%), Citrobacter braakii (1%), Proteus penneri (1%), and Sphingomonas paucimobilis (1%). In addition, 15% of samples showed no bacterial growth, which may reflect bacterial loss due to stomach acidity, post-harvest handling, or natural variability in microbial load.

Overall, members of the Enterobacteriaceae family—particularly Klebsiella, Escherichia, Raoultella, Citrobacter, and Enterobacter—comprised the largest proportion of isolates. Other genera such as Aeromonas, Pseudomonas, and Sphingomonas were detected but in comparatively lower frequencies. This distribution reflects the bacterial diversity present in the stomach environment of D. macrosoma.

Table 2. *Frequency Distribution of Bacterial Species Isolated From D. macrosoma (n = 100)*

Bacterial Species	Freq.	%
Klebsiella pneumoniae	25	25%
Escherichia coli	21	21%
Raoultella ornithinolytica	10	10%
Citrobacter freundii	9	9%
Enterobacter cloacae	6	6%
Aeromonas sobria	4	4%
Proteus mirabilis	4	4%
Pseudomonas aeruginosa	2	2%
Aeromonas hydrophila/punctata (caviae)	1	1%
Citrobacter braakii	1	1%
Proteus penneri	1	1%
Sphingomonas paucimobilis	1	1%
No Growth	15	15%
Total	**100**	**100%**

4.3 Antimicrobial Susceptibility Profiles

Table 3. Percentage of Antibiogram Profile Based on Minimum Inhibitory Concentration (MIC)

ANTIBIOTICS	Total	Sensitive		Intermediate		Resistant		*Mean*	*SD*
		n	%	*n*	%	*n*	%		
PENICILLIN:									
1. Ampicillin	30	26	86.7	0	0	4	13.3	5.87	7.45
B-LACTAM COMBINATION AGENT:									
2. Amoxicillin/Clavulanic Acid	68	64	94.1	2	2.9	2	2.9	3.41	4.37
3. Piperacillin/Tazobactam	85	76	89.4	3	3.5	6	7.1	13.65	31.92
CEPHEMS:									
4. Cefuroxime	76	60	78.9	3	3.9	13	17.1	7.37	15.79
5. Cefuroxime Axetil	72	55	75	4	5.6	13	19.4	7.82	16.24
6. Cefoxitin	73	60	80.8	1	1.4	13	17.8	13.64	20.09
7. Ceftazidime	86	86	100	0	0	0	0	1.19	0.89
8. Ceftriaxone	84	80	95.2	0	0	4	4.8	2.1	7.11
9. Cefepime	86	86	100	0	0	0	0	1.07	0.45
CARBAPENEMS:									
10. Ertapenem	83	83	100	0	0	0	0	0.5	0
11. Imipenem	86	71	82.6	9	10.5	6	7	1.38	3.34
12. Meropenem	86	76	88.4	0	0	9	11.6	1.41	3.83
AMINOGLYCOSIDES:									
13. Amikacin	86	86	100	0	0	0	0	1.98	0.19
14. Gentamicin	86	86	100	0	0	0	0	1.01	0.11
QUINOLONES AND FLUOROQUINOLONES:									
15. Ciprofloxacin	86	85	98.8	0	0	1	1.2	0.27	0.11
LIPOPEPTIDES:									
16. Colistin + Polymyxin B	75	0	0	56	74.7	19	25.3	4.43	6.78
FOLATE PATHWAY ANTAGONISTS:									
17. Trimethoprim/ Sulfamethoxazole	84	81	96.4	0	0	3	3.6	30.95	56
		1161		78		93			

Antimicrobial susceptibility testing of the bacterial isolates from Decapterus macrosoma stomach contents was performed using VITEK® 2, with interpretation based on CLSI M100 (2024) breakpoints. The overall susceptibility pattern across all antibiotics tested is summarized in Table 3. The number of isolates tested for each drug, and the proportions classified as sensitive, intermediate, or resistant, are reported as percentages.

β-lactams and β-lactam/β-lactamase inhibitor combinations

For the penicillin group, ampicillin showed 86.7% susceptibility, with 13.3% of isolates classified as resistant (30 isolates tested). Among the β-lactam/β-lactamase inhibitor combinations, amoxicillin–clavulanic acid retained high activity, with 94.1% of isolates sensitive and only 2.9% resistant (n = 68). Piperacillin–tazobactam also

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performed well, with 89.4% susceptibility and 7.1% resistance (n = 85), and a small proportion (3.5%) categorized as intermediate.

Cephalosporins

Within the cephalosporin class, resistance was more variable. Cefuroxime and cefuroxime axetil showed susceptibility rates of 78.9% and 75.0%, respectively, with resistance observed in 17.1% and 19.4% of isolates (n = 76 and n = 72). Cefoxitin had 80.8% susceptible and 17.8% resistant isolates (n = 73). In contrast, higher-generation cephalosporins showed very strong performance: ceftazidime and cefepime achieved 100% susceptibility (no resistant isolates among 86 tested), while ceftriaxone remained highly effective with 95.2% susceptibility and 4.8% resistance (n = 84).

Carbapenems

For the carbapenems, ertapenem showed 100% susceptibility (n = 83, no resistant or intermediate isolates). Imipenem exhibited 82.6% susceptibility, 10.5% intermediate results, and 7.0% resistance (n = 86). Meropenem had 88.4% susceptible isolates, with 11.6% resistant (n = 86). Overall, carbapenems remained among the most active agents in the panel.

Aminoglycosides and Fluoroquinolone

The aminoglycosides amikacin and gentamicin both demonstrated 100% susceptibility across all 86 isolates tested, with no intermediate or resistant classifications. The fluoroquinolone ciprofloxacin also retained excellent activity, with 98.8% of isolates susceptible and only 1.2% resistant (n = 86).

Polymyxins and Folate Pathway Antagonist

In contrast, the lipopolypeptide combination colistin + polymyxin B showed the least favorable profile. Among 75 isolates tested, none were classified as susceptible; 74.7% were intermediate and 25.3% were resistant. For the folate pathway antagonist trimethoprim–sulfamethoxazole, susceptibility remained high at 96.4%, with 3.6% resistant isolates (n = 84).

Multidrug resistance

Inspection of species-specific antibiogram tables (corresponding to individual taxa such as Klebsiella, Escherichia, Raoultella, and others) indicates that a subset of isolates exhibited resistance to three or more antibiotic classes, meeting the operational definition of multidrug resistance (MDR). However, MDR patterns were not universal; many isolates remained fully susceptible to carbapenems, aminoglycosides, and ciprofloxacin. Detailed distribution of resistant classes per species is presented in the species-level tables and is interpreted further in the Discussion.

In summary, the antibiogram profile in Table 3 shows that most isolates from D. macrosoma stomach contents were susceptible to higher-generation cephalosporins, carbapenems, aminoglycosides, ciprofloxacin, and trimethoprim–sulfamethoxazole, while notable pockets of resistance were observed to ampicillin, earlier-generation cephalosporins, and especially colistin/polymyxin B.

4.4 Correlation Between Microplastic Load and Antibiotic Resistance

Multiple statistical procedures were employed to examine whether microplastic contamination in Decapterus macrosoma was associated with antimicrobial resistance patterns observed in bacterial isolates.

4.4.1 Correlation of Weight and Size with Microplastic Count and Antibiotic Resistance

As presented in Table 4, fish weight and size showed no statistically significant associations with the number of microplastics or with the number of antibiotic-resistant phenotypes. Correlations were uniformly weak (r = 0.023 to –0.168), and all p-values exceeded the 0.05 threshold. These findings indicate that morphological attributes of the fish were not predictive of microplastic ingestion or the presence of resistant bacteria.

Table 4. *Correlation Between Weight, Size, Microplastic Count, and Number of Resistant Antibiotics in Decapterus macrosoma*

	Pearson r	*p* value	Interpretation
Weight vs			
Number of microplastics	0.065	0.5206	Not significant
Number of resistant antibiotics	-0.168	0.0944	Not significant
Size vs			
Number of microplastics	0.023	0.821	Not significant
Number of resistant antibiotics	0.063	0.5331	Not significant

4.4.2 Microplastic Count and MIC Values of Resistant Isolates

A Pearson correlation test was conducted to examine the relationship between microplastic count per fish and the resistance burden of isolates (i.e., the number of antibiotics classified as resistant, R). The correlation was weak and did not reach statistical significance at $p < 0.05$.

The resulting correlation was weak and negative ($r = -0.2945$), with a p-value of 0.0688, indicating that the association did not reach statistical significance. Although the negative direction suggests that higher microplastic counts might correspond to slightly lower MIC values, the effect size is small and insufficient to establish any meaningful or predictive relationship between microplastic load and elevated MICs.

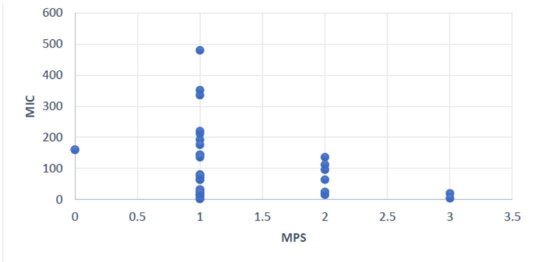

Figure 1. *Correlation between microplastics (MPS) and resistant minimum inhibitory concentration (MIC)*

4.4.3 Association Between Microplastic Presence and Resistant Bacteria

Table 5. *Association between microplastics and resistant minimum inhibitory concentration (MIC)*

Microplastics	Non-Resistant Bacteria	With Antibiotic Resistant Bacteria	Fisher's Exact Test Exact Sig. (2-sided)	*p* value
Without MPS	4	2	1.000	0.566
With MPS	57	37		

A complementary categorical analysis was performed using Fisher's Exact Test (Table 5). Fish were classified into two groups—with microplastics and without microplastics—and cross-tabulated against the presence or absence of antibiotic-resistant bacteria. The Fisher's Exact Test yielded a value of 1.000, with $p = 0.566$, demonstrating no statistically significant association between microplastic ingestion and the presence of resistant bacterial isolates. Both groups showed similar proportions of resistant and non-resistant bacteria.

Across all statistical tests applied—correlations involving weight and size, Pearson correlation of microplastic count and MIC values, and Fisher's Exact Test for categorical association—the results consistently demonstrate no evidence of a statistically significant relationship between microplastic contamination and antimicrobial resistance in *D. macrosoma* samples examined. Effect sizes were uniformly small, and significance thresholds were not reached in any analysis.

4.5 Discussion

The present study examined microplastic contamination, bacterial community composition, and antimicrobial resistance (AMR) profiles in Decapterus macrosoma (galunggong) sourced from Cavite, Philippines—a major landing site for small pelagic fishes and an area previously associated with heavy anthropogenic pressures. The findings contribute to the growing body of literature describing the ecological and public health implications of microplastics and microbe–plastic interactions in marine food resources. This discussion synthesizes the results, interprets trends relative to earlier research, and outlines the methodological constraints that shape the conclusions.

Microplastic Occurrence in D. macrosoma

Microplastic ingestion was widespread among the sampled galunggong, with 94% of fish containing at least one microplastic particle. This high prevalence reflects the broader global and national context wherein aquatic organisms routinely ingest microplastics originating from riverine inflows, wastewater discharges, and coastal urbanization. Consistent with studies conducted in Philippine water bodies, the dominant form observed was fibrous microplastics, which are widely attributed to textile laundering effluents, degraded fishing gear, and domestic waste inputs. Although fragments were also present, fibers remain the most common microplastic morphology in regions adjacent to densely populated settlements.

The microplastic load per fish was relatively low (0–4 particles per individual), suggesting chronic low-level exposure rather than acute contamination. Similar particle burdens have been documented in small pelagic fishes from other Southeast Asian coastal environments, where the trophic level and feeding behavior of species such as *Decapterus* make them prone to ingesting fibers suspended in the water column. However, the study did not include polymer-type identification, which limits inferences regarding specific sources or degradation patterns of the ingested particles. Without spectroscopic confirmation (e.g., FTIR or Raman analysis), morphological classification remains preliminary. Nevertheless, the ubiquity of microplastics in galunggong aligns with regional patterns of coastal pollution and underscores the persistent exposure of commonly consumed fish species to anthropogenic debris.

Bacterial Diversity and Dominant Taxa

The VITEK® 2 system identified a diverse set of Gram-negative bacterial species associated with

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the stomach contents of D. macrosoma. The predominance of members of the Enterobacteriaceae—particularly Klebsiella pneumoniae, Escherichia coli, Raoultella ornithinolytica, and Citrobacter freundii—is consistent with earlier reports that coastal fish gastrointestinal tracts often harbor bacteria originating from sewage-impacted waters, sediment re-suspension, or naturally occurring gut microbiota. Additional isolates such as Aeromonas, Pseudomonas, and Sphingomonas genera appear frequently in aquatic environments and have been similarly reported in studies of microplastic-associated biofilms.

The clustering of Enterobacteriaceae as the dominant taxa parallels findings from other microplastics and plastisphere studies, wherein these genera are known to colonize both biological and artificial substrates. Although this study did not directly assess microbial colonization on plastic surfaces, the overlap between environmental Enterobacteriaceae and organisms isolated here is consistent with literature suggesting that microplastics may serve as potential carriers of opportunistic bacteria. However, it must be emphasized that the present dataset reflects organisms isolated from stomach contents, not specifically from microplastic biofilms. Therefore, the distinction between gut-resident bacteria and incidental ingestion of environmental microorganisms cannot be definitively resolved.

Antimicrobial Susceptibility Patterns

The antimicrobial susceptibility profiles revealed high sensitivity to carbapenems, aminoglycosides, fluoroquinolones, and fourth-generation cephalosporins. Ertapenem, amikacin, gentamicin, ciprofloxacin, ceftazidime, and cefepime exhibited nearly universal susceptibility. These results mirror trends reported in aquatic AMR studies, where many environmental Enterobacteriaceae remain susceptible to higher-generation antibiotics despite widespread exposure to polluted waters.

Conversely, earlier-generation β-lactams such as ampicillin, cefuroxime, cefuroxime axetil, and cefoxitin showed higher resistance rates. This pattern is typical of both aquatic and clinical Enterobacteriaceae, which often carry chromosomal or plasmid-mediated resistance mechanisms against narrow-spectrum penicillins and cephalosporins. The most notable finding in the susceptibility panel was the elevated level of non-susceptibility to colistin + polymyxin B, with 25.3% of isolates classified as resistant and the remainder categorized as intermediate. Polymyxin resistance has been increasingly reported in environmental isolates, particularly those exposed to effluents from aquaculture, livestock runoff, or wastewater treatment plants. While this study cannot attribute causation, the reduced susceptibility to polymyxins warrants further monitoring due to their role as last-line agents in human medicine.

A subset of isolates met the criteria for multidrug resistance (MDR), especially among Klebsiella, Escherichia, and Raoultella. These genera are frequently implicated in AMR propagation in aquatic systems. Their detection in galunggong emphasizes the permeability between environmental reservoirs and human-associated bacterial lineages, although the cross-sectional nature of the study limits conclusions regarding transmission pathways.

Microplastics and Antimicrobial Resistance: Integration of Findings

A central aim of the study was to explore the potential association between microplastic ingestion and the occurrence of antibiotic-resistant bacteria. Across all statistical tests conducted, no significant relationship was found. Pearson's correlation between microplastic count and MIC values yielded a small, negative, and non-significant coefficient. The categorical Fisher's Exact Test—comparing fish with microplastics against those without—similarly demonstrated no significant association with resistance outcomes.

These findings contrast with several laboratory-based studies showing that microplastics can facilitate bacterial adhesion, horizontal gene transfer, and persistence of resistant strains. However, the discrepancy may be explained by methodological and ecological differences. Laboratory studies often expose microplastics to high concentrations of bacteria and antibiotics under controlled conditions, whereas natural marine environments involve complex interactions among currents, feeding behaviors, and microbial community dynamics. Furthermore, the microplastic load in the sampled galunggong was relatively low, possibly insufficient to exert a measurable selective or vector-mediated effect.

Another factor is data structure. Because the present study did not generate specimen-level pairing between individual microplastic particles and specific bacterial isolates, the capacity to detect nuanced relationships between microplastic ingestion and AMR is limited. The statistical tests thus reflect organism-level rather than particle-level associations. While this approach remains valid, it inherently reduces sensitivity to detect subtle associations.

Methodological Strengths and Limitations

The study incorporates several methodological strengths. The use of VITEK® 2 ensures standardized and reproducible bacterial identification and susceptibility profiling. MIC-based interpretation following CLSI M100 guidelines enhances the reliability of AMR classification. The sampling size (n = 100) is sufficient for descriptive and correlation analyses, and follows precedents in fish-based microplastic research.

However, limitations must be acknowledged. First, the inability to perform polymer identification restricts inferences about microplastic sources, persistence, and chemical composition. Second, microplastic morphological characteristics were not quantified beyond general observation, limiting the depth of plastisphere-related interpretations. Third, the absence of paired specimen-level data linking specific microplastic particles to bacterial isolates prevents direct assessment of microplastics as microbial carriers. Fourth, the study employed a single landing site, which constrains generalizability across other regions or seasons. Finally, the cross-sectional design captures only a snapshot of contamination dynamics, precluding causal interpretations.

Implications and Future Directions

Despite these limitations, the study provides valuable baseline data for understanding microplastic and AMR interactions in a widely consumed fish species in the Philippines. The findings reinforce the need for integrated environmental surveillance that includes microplastics, microbial communities, and antibiotic resistance determinants. Future studies would benefit from spectroscopic polymer analysis, higher-resolution microplastic quantification, and microbe–plastic co-localization techniques such as SEM-EDS or confocal microscopy. Expanding to multi-site and temporal sampling could also clarify spatial and seasonal trends. In addition, genome-level analysis of resistance genes (e.g., via whole-genome sequencing or qPCR of AMR markers) may yield clearer insights into resistance transmission pathways.

5. Summary, Conclusions and Recommendations

5.1 Summary

This study investigated the presence of microplastics, the composition of bacterial isolates, and the antimicrobial resistance (AMR) patterns associated with Decapterus macrosoma (galunggong) harvested from Cavite, Philippines. A total of 100 fish samples were analyzed to quantify microplastic ingestion, identify bacterial species using VITEK® 2, determine antimicrobial susceptibility through MIC-based interpretation following CLSI M100 (2024), and assess potential correlations among microplastic load, fish attributes, and resistance profiles.

Microplastics were detected in 94% of fish, with individual loads ranging from 0 to 4 particles. Fibers were the predominant morphology observed, consistent with patterns reported in coastal environments influenced by domestic and urban effluents. Although microplastic polymer type could not be determined due to limited instrumentation, the overall contamination pattern reflected ongoing environmental exposure in marine ecosystems.

Bacterial cultures revealed a diverse assemblage dominated by Enterobacteriaceae. The most frequently isolated species were Klebsiella pneumoniae, Escherichia coli, Raoultella ornithinolytica, and Citrobacter freundii. Additional isolates included Enterobacter cloacae, Aeromonas sobria, Proteus mirabilis, Pseudomonas aeruginosa, Sphingomonas paucimobilis, and others in low frequencies. These taxa are common in aquatic environments affected by municipal runoff, sediment influence, and naturally occurring gut microbiota.

Antimicrobial susceptibility testing showed high sensitivity to carbapenems, aminoglycosides, ciprofloxacin, and fourth-generation cephalosporins. Elevated resistance was noted for ampicillin, cefuroxime, cefuroxime axetil, and cefoxitin, while colistin + polymyxin B showed the least favorable susceptibility profile. A subset of isolates exhibited multidrug resistance (MDR), although MDR occurrence was not widespread across the dataset.

Correlation analyses revealed no statistically significant relationships among fish weight, size, microplastic count, and the number of resistant antibiotic classifications. Additionally, Pearson's correlation between microplastic load and MIC values yielded a weak, non-significant association, and Fisher's Exact Test showed no significant relationship between microplastic presence and the occurrence of resistant bacteria. The results collectively indicate that, within the constraints of the dataset, microplastic ingestion in D. macrosoma

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was not associated with AMR patterns in recovered bacterial isolates.

5.2 Conclusion

The findings of this study demonstrate that Decapterus macrosoma from Cavite waters exhibit high microplastic exposure, primarily in the form of fibrous particles consistent with anthropogenic pollution sources. The bacterial communities isolated from the stomach contents were dominated by Enterobacteriaceae and other genera commonly reported in aquatic and coastal ecosystems. While resistance to certain β-lactams and polymyxins was observed, the majority of isolates remained susceptible to broad-spectrum and higher-generation antibiotics.

Importantly, the study found no statistically significant evidence linking microplastic ingestion to the presence or extent of antimicrobial resistance in associated bacterial isolates. Both continuous-variable and categorical analyses indicated negligible effect sizes and non-significant associations. These results suggest that—under the specific environmental conditions, limited microplastic loads, and sampling structure of this study—microplastic ingestion does not appear to influence the occurrence of resistant organisms in D. macrosoma.

The conclusions emphasize that microplastic contamination and AMR remain critical environmental and public health concerns, but their interaction in natural marine settings requires more targeted and higher-resolution approaches. Future investigations must incorporate polymer-specific identification, direct analysis of microbe–plastic interactions, and broader spatial–temporal sampling frameworks to clarify potential links between plastic pollution and AMR ecology.

5.3 Recommendations

Based on the results and methodological limitations of the study, the following recommendations are offered:

a. Conduct polymer-specific microplastic identification. Future research should employ FTIR, Raman spectroscopy, or comparable instrumentation to determine polymer types and trace contamination sources more accurately.
b. Implement higher-resolution microplastic characterization. Standardizing particle classification by size, shape, and color will enable more robust comparisons with regional and international datasets.
c. Integrate microbe–plastic co-localization analyses. Direct examination of bacterial communities attached to microplastic particles using SEM-EDS, confocal microscopy, or metabarcoding approaches is recommended.
d. Expand sampling across multiple landing sites and seasons. Multi-site and longitudinal sampling can clarify spatial and temporal variability in microplastic exposure and AMR dynamics.
e. Enhance specimen-level pairing of microplastics and bacterial isolates. A structured dataset linking the exact microplastic load of each fish with its corresponding antibiogram will allow more definitive testing of MP–AMR associations.
f. Include molecular assays for resistance gene profiling. Tools such as qPCR for AMR markers or whole-genome sequencing of isolates can provide deeper insights into gene-level mechanisms.
g. Strengthen environmental monitoring of coastal pollution inputs. Local agencies and fisheries stakeholders may consider targeted surveillance of riverine discharge points, wastewater outputs, and coastal hotspots known to contribute microplastics and resistant bacteria.
h. Promote public awareness and policy initiatives on waste reduction. Strategies addressing plastic disposal, wastewater treatment, and microplastic mitigation can reduce long-term ecological impact.

Collectively, these recommendations can support more comprehensive environmental and food safety assessments, addressing key knowledge gaps in marine microplastic contamination and aquatic AMR ecology.

5.4 Final Note

This study establishes foundational evidence on microplastic ingestion and bacterial resistance patterns in a widely consumed Philippine fish species. Although no direct link between microplastics and AMR was observed, the findings reinforce the need for integrated monitoring that spans environmental science, microbiology, and public health. Continued interdisciplinary research will be essential in anticipating and mitigating emerging risks in marine ecosystems and food systems.

6. References

Abbasi, S., Keshavarzi, B., Moore, F., Turner, A., Kelly, F. J., Dominguez, A. O., & Jaafarzadeh, N. (2019). Distribution and potential health impacts of microplastics and microrubbers in air and street dusts from Asaluyeh County, Iran. Environmental Pollution, 244, 153–164. https://doi.org/10.1016/j.envpol.2018.10.039

Adinortey, C. A., Aheto, D. W., Boateng, A. A., & Agbeko, R. (2020). Multiple Antibiotic Resistance-Coliform Bacteria in Some Selected Fish Farms of the Central Region of Ghana. Scientifica, 2020. https://doi.org/10.1155/2020/6641461

Baptista Neto, J. A., Gaylarde, C., Beech, I., Bastos, A. C., da Silva Quaresma, V., & de Carvalho, D. G. (2019). Microplastics and attached microorganisms in sediments of the Vitória bay estuarine system in SE Brazil. Ocean and Coastal Management, 169, 247–253. https://doi.org/10.1016/j.ocecoaman.2018.12.030

Borongan, G., & Naranong, A. (2022). Practical Challenges and Opportunities for Marine Plastic Litter Reduction in Manila: A Structural Equation Modeling. Sustainability (Switzerland), 14(10). https://doi.org/10.3390/su14106128

Breijyeh, Z., Jubeh, B., & Karaman, R. (2020). Resistance of gram-negative bacteria to current antibacterial agents and approaches to resolve it. Molecules, 25(6). https://doi.org/10.3390/molecules25061340

Britannica. (n.d.). Cavite, Philippines. Retrieved from https://www.britannica.com/place/Cavite

Campanale, C., Massarelli, C., Savino, I., Locaputo, V., & Uricchio, V. F. (2020). A detailed review study on potential effects of microplastics and additives of concern on human health. In International Journal of Environmental Research and Public Health (Vol. 17, Issue 4). MDPI AG. https://doi.org/10.3390/ijerph17041212

Cao, J., Yang, Q., Jiang, J., Dalu, T., Kadushkin, A., Singh, J., Fakhrullin, R., Wang, F., Cai, X., & Li, R. (2022). Coronas of micro/nano plastics: A key determinant in their risk assessments. Particle and Fibre Toxicology, 19(1), 55.

Cave, R., Cole, J., & Mkrtchyan, H. V. (2021). Surveillance and prevalence of antimicrobial resistant bacteria from public settings within urban built environments: Challenges and opportunities for hygiene and infection control. Environment International, 157. https://doi.org/10.1016/j.envint.2021.106836

Chai, B., Li, X., Liu, H., Lu, G., Dang, Z., & Yin, H. (2020). Bacterial communities on soil microplastic at Guiyu, an e-waste dismantling zone of China. Ecotoxicology and Environmental Safety, 195, 110521. https://doi.org/10.1016/j.ecoenv.2020.110521

Clinical and Laboratory Standards Institute. (2024). CLSI M100 Performance Standards for Antimicrobial Susceptibility Testing (34th ed.).

Dalu, T., Themba, S. T., Dondofema, F., Wu, N., & Munyai, L. F. (2024). Assessing microplastic abundances in freshwater fishes in a subtropical African reservoir. Discover Sustainability, 5(1), 589. https://doi.org/10.1007/s43621-024-00589-5

Díaz-Mendoza, C., Mouthon-Bello, J., Pérez-Herrera, N. L., & Escobar-Díaz, S. M. (2020). Plastics and microplastics, effects on marine coastal areas: a review. In Environmental Science and Pollution Research (Vol. 27, Issue 32, pp. 39913–39922). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s11356-020-10394-y

Florence, D., Onda, L., Purganan, D. J., & Tolentino, M. P. (2020). Microbial Oceanography Studies in the Philippines and Adjacent Waters View project HABs studies in the Philippines View project. In Philippines Article in Philippine Journal of Science. https://www.researchgate.net/publication/338818951

Gonzales, B. J., Ylagan, A. R., Cabadongga, B. M., & Manzano, Z. T. (2021). Spawning of *Decapterus macrosoma* (Bleeker, 1851) "Galunggong" in Tablas.

Gufe, C., Canaan Hodobo, T., Mbonjani, B., Majonga, O., Marumure, J., Musari, S., Jongi, G., Makaya, P. V., & Machakwa, J. (2019). Antimicrobial Profiling of Bacteria Isolated from Fish Sold at Informal Market in Mufakose, Zimbabwe. International Journal of Microbiology, 2019. https://doi.org/10.1155/2019/8759636

Hajjar, R., Ambaraghassi, G., Sebajang, H., Schwenter, F., & Su, S. H. (2020). Raoultella ornithinolytica: emergence and resistance. Infection and drug resistance, 1091-1104.

Hamed, M., Soliman, H. A. M., Badrey, A. E. A., & Osman, A. G. M. (2021). Microplastics induced histopathological lesions in some tissues of tilapia (Oreochromis niloticus) early juveniles. Tissue and Cell, 71. https://doi.org/10.1016/j.tice.2021.101512

Hamprecht, A., Sattler, J., Noster, J., Stelzer, Y., Fuchs, F., Dorth, V., Gatermann, S. G., & Göttig, S. (2023). Proteus mirabilis – analysis of a concealed source of carbapenemases and development of a diagnostic algorithm for detection. Clinical Microbiology and Infection, 29(9), 1198.e1-1198.e6. https://doi.org/10.1016/j.cmi.2023.05.032

Hossain, M. R., Jiang, M., Wei, Q. H., & Leff, L. G. (2019). Microplastic surface properties affect bacterial colonization in freshwater. Journal of Basic Microbiology, 59(1), 54–61. https://doi.org/10.1002/jobm.201800174

Hossain, M. B., Pingki, F. H., Azad, M. A. S., Nur, A. A. U., Banik, P., Sarker, P. K., ... & Yu, J. (2024). Accumulation, tissue distribution, health hazard of microplastics in a commercially important cat fish, Silonia silondia from a tropical large-scale estuary. Frontiers in Sustainable Food Systems, 8, 1372059.

Jimenez, C., Molina, D., Garcia, J., Quiñones, M., de la Rosa, H. K., Samson, J., & Paghasian, M. (2020). Species Composition, Abundance, and Catch Trends of Roundscads Decapterus spp. in Iligan Bay, Northern Mindanao, Philippines. Journal of Environment & Aquatic Resources, 5. https://doi.org/10.48031/msunjear.2020.05.03

Jubeh, B., Breijyeh, Z., & Karaman, R. (2020). Resistance of gram-positive bacteria to current antibacterial agents and overcoming approaches. In Molecules (Vol. 25, Issue 12). MDPI AG. https://doi.org/10.3390/molecules25122888

Kalnasa, M. L., Lantaca, S. M. O., Boter, L. C., Flores, G. J. T., & Galarpe, V. R. K. R. (2019). Occurrence of surface sand microplastic and litter in Macajalar Bay, Philippines. Marine Pollution Bulletin, 149, 110521. https://doi.org/10.1016/j.marpolbul.2019.110521

Kelly, J. J., London, M. G., McCormick, A. R., Rojas, M., Scott, J. W., & Hoellein, T. J. (2021). Wastewater treatment alters microbial colonization of microplastics. PLoS ONE, 16(1), e0244443. https://doi.org/10.1371/journal.pone.0244443

Khan, Z. A., Siddiqui, M. F., & Park, S. (2019). Current and emerging methods of antibiotic susceptibility testing. Diagnostics, 9(2). https://doi.org/10.3390/diagnostics9020049

Kowalska-Krochmal, B., & Dudek-Wicher, R. (2021). The minimum inhibitory concentration of antibiotics: Methods, interpretation, clinical relevance. Pathogens, 10(2). https://doi.org/10.3390/pathogens10020165

Leslie, H. A., van Velzen, M. J. M., Brandsma, S. H., Vethaak, A. D., Garcia-Vallejo, J. J., & Lamoree, M. H. (2022). Discovery and quantification of plastic particle pollution in human blood. Environment International, 163, 107199. https://doi.org/10.1016/j.envint.2022.107199

Magni, S., Fossati, M., Pedrazzani, R., Abbà, A., Domini, M., Menghini, M., Castiglioni, S., Bertanza, G., Binelli, A., & della Torre, C. (2024). Plastics in biogenic matrices intended for reuse in agriculture and the potential contribution to soil accumulation. Environmental Pollution, 349, 123986. https://doi.org/10.1016/j.envpol.2024.123986

Mancuso, G., Midiri, A., Gerace, E., & Biondo, C. (2021). Bacterial antibiotic resistance: The most critical pathogens. Pathogens, 10(10), 1310. https://doi.org/10.3390/pathogens10101310

Miri, S., Saini, R., Davoodi, S. M., Pulicharla, R., Brar, S. K., & Magdouli, S. (2022). Biodegradation of microplastics: Better late than never. Chemosphere, 286, 131815.

Multisanti, C. R., Ferrara, S., Piccione, G., & Faggio, C. (2025). Plastics and their derivatives are impacting animal ecophysiology: A review. Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 110149.

Murray, C. J., Ikuta, K. S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., Han, C., Bisignano, C., Rao, P., Wool, E., Johnson, S. C., Browne, A. J., Chipeta, M. G., Fell, F., Hackett, S., Haines-Woodhouse, G., Kashef Hamadani, B. H., Kumaran, E. A. P., McManigal, B., … Naghavi, M. (2022). Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. The Lancet, 399(10325), 629–655.

https://doi.org/10.1016/S0140-6736(21)02724-0

Nagar, V., Ansari, F., Vaiyapuri, M., & Joseph, T. C. (2025). Virulent and multidrug-resistant Aeromonas in aquatic environments of Kerala, India: Potential risks to fish and humans. Brazilian Journal of Microbiology. https://doi.org/10.1007/s42770-024-01601-w

Najahi, H., Banni, M., Nakad, M., Abboud, R., Assaf, J. C., Operato, L., Belhassen, M., Gomes, L., & Hamd, W. (2025). Plastic pollution in food packaging systems: impact on human health, socioeconomic considerations and regulatory framework. In Journal of Hazardous Materials Advances (Vol. 18). Elsevier B.V. https://doi.org/10.1016/j.hazadv.2025.100667

Pfohl, P., Wagner, M., Meyer, L., Domercq, P., Praetorius, A., Hüffer, T., Hofmann, T., & Wohlleben, W. (2022). Environmental Degradation of Microplastics: How to Measure Fragmentation Rates to Secondary Micro- and Nanoplastic Fragments and Dissociation into Dissolved Organics. Environmental Science and Technology, 56(16), 11323–11334. https://doi.org/10.1021/acs.est.2c01228

Philippine Statistics Authority. (2018). Fisheries statistics of the Philippines 2015–2017. PSA Fisheries Statistics Series No. 26.

Rada, B., Ramos, E., Riva, C., & Royo, N. (2019). Preliminary Study on Spawning Period and Length at Maturity of Shortfin Scad, *Decapterus macrosoma*, (Bleeker, 1851, Perciformes: Carangidae) from the Coastal Waters of San Fernando, Romblon. The Philippine Journal of Fisheries, 26(1), 35–43. https://doi.org/10.31398/tpjf/26.1.2018-0014

Sulis, G., Sayood, S., & Gandra, S. (2022). Antimicrobial resistance—the next emerging pandemic? BMJ, 379. https://doi.org/10.1136/bmj-2022-072663

Talavera, A. L., Dalida, L. F. M., & Diola, M. B. L. D. (2024). Riverine macroplastic survey along the segments of Tullahan River in Metro Manila, Philippines. Frontiers in Environmental Science, 12, 1396525. https://doi.org/10.3389/fenvs.2024.1396525

Winiarska, E., Jutel, M., & Zemelka-Wiacek, M. (2024). The potential impact of nano- and microplastics on human health: Understanding human health risks. In Environmental Research (Vol. 251). Academic Press Inc. https://doi.org/10.1016/j.envres.2024.118535

