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Short Communication

# Microplastic Contamination in Marine Fish and Shells in the Coastal Areas of Jember Regency, Indonesia

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## Abstract

Every year, it is estimated that the Indonesian seas receive 100,000-400,000 tons of plastic waste used for human consumption. Indiscriminate disposal of plastic waste will have an impact in the future. The problem of microplastics is an illustration that the use of plastic in daily activities will cause environmental ecological damage. The purpose of the study was to describe microplastic contamination in marine fish and shells in the coastal areas of Jember Regency, Indonesia. The method used is to detect and identify the type and numbers of microplastic particles in the gastrointestinal tract content of sea fish and shells obtained from fishermen around Payangan and Puger coastal Jember, Indonesia. The gastrointestinal tract was extracted with peroxide oxidation method (WPO). A light microscope was used to examine microplastic particles of types and numbers. The results showed that marine fish and shells in the coastal area of Jember Regency, Indonesia have been contaminated with microplastic. The microplastic in each marine fish and shells sample has a different type. There were microplastic types of fiber, fragments, granules, and filaments in the shells sample, while in the marine fish samples, there were all these types except granules. Fish and shellfish on the coast of Payangan and Puger had several types of microplastics detected in their gastrointestinal tract.

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## 1. Introduction

The Indonesian Sea is estimated to receive shipments of plastic waste used for human consumption in the amount of between 100,000-400,000 tons every year. This waste shipment makes human the dominant waste producers on earth (Ambari, 2019). The amount of pollution in the sea makes it a negative threat both for marine products (fish, shells, or seafood) and human health. Indiscriminate disposal of plastic waste will have an impact in the future (Galloway *et al.*, 2017). According to Carbery *et al.* (2018), more than 690 marine species have been affected by plastic waste, both small debris and small microplastic observed in the digestive tract of organisms from various trophic levels of the food chain. Microplastics already present in the intestines of fish will migrate into the lymph and other organs of the body. In humans, exposure to microplastics is mainly through ingestion of fish, inhalation, and infiltration through the skin. These microplastics can contaminate drinking water, accumulate in the food chain, and release toxic materials from plastics that can play a role in human health problems (Yuan *et al.*, 2022). Several studies have shown that *Sardinella* sp. along the waters of Java and Bali and tuna (*Euthynnus affinis*) on the island of BAAI Bengkulu, Indonesia have been contaminated with microplastic types of fiber, fragments, and films (Rijal *et al.*, 2021; Purnama *et al.*, 2021). Microplastics are commonly found in marine areas close to human activities in coastal, industrial and harbor areas (Castillo *et al.*, 2016).

Plastic waste that enters the ocean reaches millions of tons every year. The waste comes from the disposal of single-use packaging, illegal dumping, lost or damaged fishing gear, and 80% comes from land. The pandemic exacerbated these conditions by using personal protective equipment made of single-use plastic (UNIDO, 2019). People's behavior that is still low on waste management and weak enforcement of regulations by the government are factors that trigger the increase in waste generation in the ocean (Mamady, 2016; Kusumawati and Setyowati, 2018). The accumulated garbage can cause environmental pollution and can even cause flooding. These floods can act as reservoirs and sources of microplastics that are harmful to ecosystems (Rolf *et al.*, 2022). Pollution by microplastics is one of the global problems that is currently in the spotlight for environmentalists. The problem of microplastics is an example of how the use of plastic in daily activities will cause environmental ecological damage. The highest microplastic content is usually found in the rainy season when the coastal environment gets a lot of water input from rivers which contain lots of plastic fragments through the estuary (runoff). Plastic waste that is dumped into the sea has a risk impact on coastal communities. The main source of microplastics (primary) comes from plastic particles that are intentionally made small, for example, resin pellets, beads or for industrial purposes for treatment. Sources of secondary microplastics are large plastics that undergo weathering and disintegration processes from plastics that already exist in the environment. Microplastic fibers are released from laundry or shipbuilding paint materials (Thiele *et al.*, 2021). Plastic degradation and fragmentation in coastal waters have an impact on the formation of harmful secondary microplastics (Amelia *et al.*, 2021).

Microplastic is defined as a dense synthetic particle or also called a polymer matrix with regular and irregular shapes, measuring 1µm - 5µm and insoluble in water. The effects of microplastics on exposed organisms can be categorized into physical and chemical effects. Physical effects are related to the size, shape, and concentration of particles, while chemical effects are related to the chemicals they contain (Campanale *et al.*, 2020). The effects caused by this plastic waste, apart from being physically ingested by marine life, also result in the transfer of chemicals contained in the plastic material (Gallo *et al.*, 2018). The dangers arising from microplastics can be direct toxicity and bioaccumulation, especially if the size of the microplastic reaches a smaller size (nanoscale). Microplastics that accumulate continuously are called persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and organochlorine pesticides such as dichlorodiphenyltrichloroethane (DDT) or hexachlorobenzene (HCB) from microplastics (Smith *et al.*, 2018). In addition, alkylphenols, bisphenols and phthalates are also released from microplastics which are very harmful to the organism's body system (Bonfanti *et al.*, 2021). The physical and chemical properties of microplastics result in cell contaminants in the gastrointestinal tract, serving as vectors for contaminants in organisms that have ingested them. The bioaccumulation of microplastic chemicals has an impact on seafood webs starting from plankton, seabirds, fish, and humans (Carbery *et al.*, 2018).

Several forms of microplastics were detected in fish caught around the island of Java, namely fibers, fragments, films, foams, filaments, pellets, granules, and microbeads. Some of the fish found not only containing 1 type of microplastic, but more than two forms of microplastic were found. The shape of the fiber generally comes from river or estuary waters of different sizes. One of many fish with high concentrations of microplastics is Lemuru fish (Basri *et al.*, 2021). FTIR analysis showed that the highest microplastic content in fish species in coastal areas was polyethylene (PE) compared to other polymers (polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), polyvinyl chloride (PVC) and polyamide (PA) (Llorca *et al.*, 2020). The toxic effects of microplastics on fish and humans are considered a global problem because fish are a source of protein that is vital for human growth and development. Organisms exposed to microplastic contamination experience tissue damage, oxidative stress and altered gene expression associated with the immune system. Several disorders due to microplastic contaminants in fish cause neurotoxicity, growth retardation and behavioral abnormalities (Bhuyan, 2022).

There are 8 coastal areas in Jember Regency, Indonesia. The beach that is often visited as a place of tourism is the southern side of the coast. Among them are Watu Ulo Beach, Papuma Beach, and Puger Beach. The results of research on pollution of sea salt, the average heavy metal content of lead (Pb) in Pamekasan Regency is still below the maximum limit specified in SNI 3556-2010 and SNI 7387-2009, which is < 10 ppm with the lowest Pb content being 0.066 ppm and the highest 0.162 ppm (Samsiyah *et al*., 2019). Plastic waste which will then become microplastic can have a negative impact on humans. Microplastics will probably accumulate in the digestive tract of animals that eat plastic, including fish and shells. The results of the study found that the highest concentration of microplastics in shells was 4 particles/gram. That is, in 250 grams of shells there are 1,000 microplastic particles in it. According to the results of the FAO Department of Fisheries and Aquaculture research, the following are some of the health hazards of microplastics that are suspected of disrupting the endocrine system, disrupting the immune system, and potentially causing oxidative stress and changes in DNA. In the future, it is estimated that the number of microplastics will be more than the number of fish in the ocean so the amount of microplastic waste is estimated to be more than the number of plankton in the sea (Ambari, 2019). Plastic waste which will then become microplastic can have a negative impact on marine life and humans. It is necessary to take preventive measures so that health problems do not occur that are increasingly complex and aquatic ecosystems can be maintained.

Health problems are complex problems as well as solutions to public health problems, not only in terms of their own health but must be seen from all aspects. There are four factors that influence the problem of public health status, namely the environment, behavior, health services, and genetics. These factors have a direct effect on health and influence each other. Health status can be achieved optimally if these four factors together have optimal conditions. There are eight coastal areas in Jember Regency, Indonesia. The coastal areas that are often visited as a place of tourism are Payangan Beach, Watu Ulo Beach, Papuma Beach and Puger Beach. These four coastal areas are used as tourism spots and culinary tourism spots with fish caught by fishermen. To find fish, people usually also buy fish on Puger beach because Puger is a marine fisheries sector that has a TPI (Fish Auction Place) (Hartejo and Soehartono, 2012). The amount of pollution in the sea makes a negative threat both to marine products (fish, shellfish, or seafood) and a threat to public health. Based on preliminary studies, found a lot of garbage around the sea. People were also found throwing garbage around the sea. The community still does not have awareness regarding the importance of maintaining the cleanliness of the aquatic environment. Behavior in consuming fish in coastal communities is obtained from the waters that are around it. Research evidence shows that the condition of the waste processing site still does not meet health requirements, meaning that the waste disposed of by coastal communities is disposed of directly into the sea and the waste that is disposed of is mostly plastic waste (Ningrum, 2017). Plastic waste in the ocean will break down into small particles called microplastics. This microplastic will affect the life of fish and fish that are eaten by humans, it will affect human health. It has never been known how microplastic contamination of fish and shellfish consumed by humans comes from the coastal area of Jember, Indonesia. The research related to microplastic contamination in marine fish and shellfish is still minor, especially at Payangan and Puger beaches, Jember Regency, Indonesia. Research on microplastic contamination is important to do to prevent the harm caused. Therefore, it is necessary to conduct further research related to the presence of microplastics that contaminate marine biota such as fish and shellfish which can cause health problems for the community. The purpose of this study was to study microplastic contamination in marine fish and shells in the coastal area of Jember Regency, Indonesia.

## 2. Materials and Methods

### *2.1 Materials*

The material used in the study was gastrointestinal tract sea fish and shellfish, H2O2, filter paper, and NaCl.

### *2.2 Methods*

The research sites are located on Puger and Payangan Beaches. Puger Beach is located in Puger


**Figure 1.** Research site map on Puger Beach


**Figure 2. (a)** Garbage Pollution on Puger Beach; **(b)** Garbage Pollution on Payangan Beach

District, while Payangan Beach is located in Ambulu District (Figure 1). Puger Beach is one of the beaches owned by the government of Jember Regency with the coordinates of -8.379548º; 113.468º. This beach is + 35 km south of Jember City with an area of 2.5 hectares. This tour can be accessed by using all types of vehicles. The facilities provided include TPI (Fish Auction Place), food and drink stalls, Polairud Post and SAR, prayer rooms, bathrooms and toilets, parking lots, hot mix roads. Payangan Beach is a tourist area located in the same village and sub-district as Watu Ulo Beach, namely Sumberrejo Village and Ambulu District with coordinates of -8.43445º; 113.581825º. Payangan Beach is a state-owned beach, not owned by the Jember government. This beach was developed by the surrounding community as a form of community empowerment and participation in developing tourism.

The northern part of the research area is bordered by fishermen's housing, the eastern part is bordered by boat routes (Figure 1). Puger and Payangan beaches are one of the beaches that have garbage contamination so that the beaches are polluted. The presence of garbage that is disposed of carelessly can cause microplastic contamination in aquatic ecosystems. Puger and Payangan Beach is polluted by garbage dumped by the community around the beach (Figure 2). This waste can be a source of microplastic contamination of aquatic ecosystems.

The subject of this research was sea fish and shells obtained from fishermen around Payangan and Puger Coastal Jember, Indonesia. Eight samples included four sea fish and four shells with uniform lengths and sizes. Microplastic type analysis in the gastrointestinal tract using the peroxide oxidation method (WPO). The method was briefly as follows. The weight and length of the fish and shellfish were measured, and they were rinsed with distilled water to remove the external contaminants. The gastrointestinal tract was extracted and dried in an oven at 90°C for 48 hours. The gastrointestinal tract was dissected, and the samples were removed and put into a glass beaker. The solution of 0.05 M Fe and hydrogen peroxide solution (30%) was added to the sample, heated at 75°C for 30 minutes and mixed using a magnetic stirrer at 120 rpm. To increase the density of the solution test, the cooled sample was mixed with 12 grams of NaCl salt. The density of the solution test was to separate microplastic particles and deposits. After staying for 24 hours, the sample was filtered using microfiber filter papers with a diameter of 47 mm. The type and numbers of microplastic were determined using an Olympus BX-41 light microscope (Sulistyo *et al.*, 2021).

**Table 1.** Data on length and weight of tuna fish and shells in the coastal area of Jember Regency, Indonesia

| | Tuna Fish | | | Shells | |
|---|---|---|---|---|---|
| | Length (cm) | Weight (g) | | Length (cm) | Weight (g) |
| 1st Tuna Fish | 23.6 | 197 | 1st Shells | 7.4 | 20.4 |
| 2nd Tuna Fish | 25.9 | 206 | 2nd Shells | 5.7 | 23.6 |
| 3rd Tuna Fish | 29.7 | 318 | 3rd Shells | 6.3 | 19.7 |
| 4th Tuna Fish | 20.4 | 169 | 4th Shells | 6.9 | 23.8 |
| **Average** | **24.9** | **199** | **Average** | **21.1** | **21.9** |

**Table 2.** Taxonomic classification of tuna fish and shells in the coastal area of Jember Regency, Indonesia

| Taxonomic | Tuna Fish (*Euthynnus affinis*) | Shells (*Perna viridis*) |
|---|---|---|
| Kingdom | Animalia | |
| Phylum | Chordata | Mollusca |
| Sub Phylum | Vertebrata | |
| Class | Pisces | Bivalvia |
| Sub Class | Teleostei | |
| Ordo | Percomorphi | |
| Family | Scombriade | |
| Genus | *Euthynnus* | *Perna* |
| Species | *Euthynnus affinis* | *Perna viridis* |

The samples used were tuna and shellfish. Each sample amounted to four samples. Each sample has a different length and weight (Table 1). For tuna, 3rd Tuna Fish has the longest fish length of the other three samples, which is 29.7 cm, whereas in shellfish, 1st Shellfish has the longest of the other three samples, which is 7.4 cm.

Shells are organisms that belong to the kingdom animalia (Table 2). Shells include animals from the class bivalves, this class always has a pair of valve shells, so it is called bivalves. Tuna Fish are organisms that belong to the kingdom animalia. Tuna fish is a group of small tuna with elongated body characteristics, no scales with a hard dorsal fin texture. Tuna Fish belonging to the Scombridae family of the genus *Euthynnus*.


**Figure 3.** Types of microplastics in marine fish samples, a) fiber; b) fragments; c) filaments


**Figure 4.** Types of microplastics in shells samples, a) fiber; b) fragments; c) granule; d) filaments

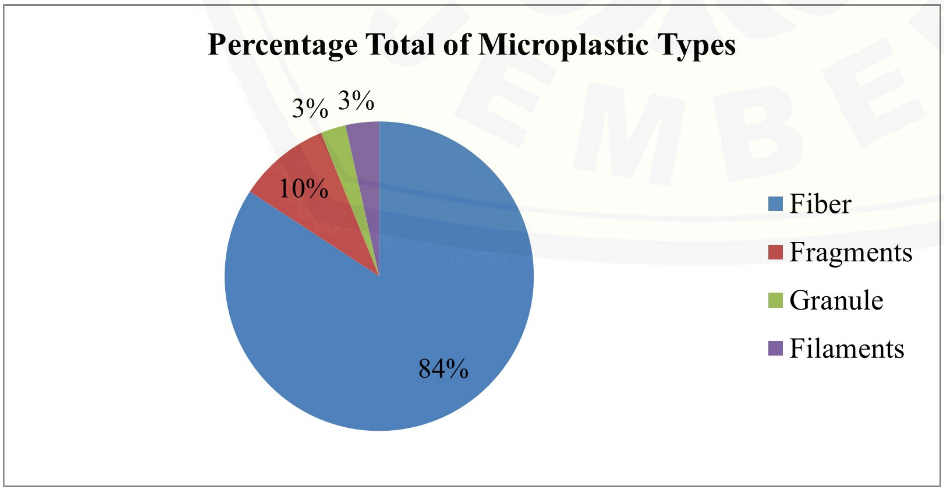


**Figure 5.** Percentage total of microplastics types

## 3. Results and Discussion

### 3.1 Results

It is known that there are several types of microplastics contained in samples of marine fish and shellfish in the coastal area of Jember Regency with a total of 114 particles (Table 3). The total number of microplastics in marine fish is 65 particles and 49 particles in shellfish. The most common microplastic found in marine fish and shellfish samples was fiber. In marine fish, there are no microplastic granules.

**Table 3.** Types of microplastics found in marine fish and shells in the coastal area of Jember Regency, Indonesia

| | Type of Microplastics | | | | Total |
|---|---|---|---|---|---|
| | Fiber | Fragment | Granula | Filament | |
| 1st Fish | 21 | 0 | 0 | 0 | 21 |
| 2nd Fish | 24 | 3 | 0 | 0 | 27 |
| 3rd Fish | 7 | 1 | 0 | 1 | 9 |
| 4th Fish | 8 | 0 | 0 | 0 | 8 |
| 1st Shells | 14 | 1 | 0 | 1 | 16 |
| 2nd Shells | 6 | 2 | 0 | 0 | 8 |
| 3rd Shells | 7 | 0 | 1 | 1 | 9 |
| 4th Shells | 9 | 4 | 2 | 1 | 16 |
| **Total** | **96** | **11** | **3** | **4** | **114** |

### 3.2 Discussion

Microplastic problems can be identified through several tests that produce conclusions. Microplastics are small plastic wastes measuring <5 mm mostly from the decomposition of large plastics (Mazurais *et al*., 2014; Setälä *et al*., 2014; Kühn *et al*., 2015) which are grouped into two types of microplastics, namely secondary and primary, primary microplastics are the result of plastic production in micro form, such as microbeads in skin care products, while secondary microplastics are part, fragments, of a larger plastic fragmentation product (Zhang *et al*., 2017).

Types of microplastics contained in samples of marine fish and shellfish in the coastal area of Jember Regency with a total of 114 particles. The total number of microplastics in marine fish is 65 particles and 49 particles in shellfish. The most common microplastic found in marine fish (Figure 3) and shellfish samples (Figure 4). In marine fish, there are no microplastic granules (Figure 3). Fiber type microplastics can be sourced from clothes washing activities that produce yarn residue and fishing activities in catching fish from fishing gear, namely fishing lines and nets which then break down into small plastic particles in the waters (Browne, 2015). The existence of this type of fiber microplastic can be seen that there are many human activities because the fiber is generally sourced from rope or clothing thread (Alam *et al*., 2019). In addition, the type of fiber can also indicate the high activity of fishermen in looking for fish because it is associated with the degradation of ropes and fishing nets. Microplastic fiber type comes from synthetic fabrics that can be released due to washing clothes, fishing gear, industrial raw materials, household appliances, and plastic bags that are degraded in the environment. Fiber is a microplastic whose physical shape is elongated and thin like a fishing line or net (Winkler *et al*., 2020; Lie *et al*., 2018; Wicaksono, 2018), this type of microplastic fiber is known to last longer on the surface of the water because of its relatively low density. Fiber-type microplastics are more commonly found in fish samples with the total amount of 84% (Figure 5) because fiber is easier to enter through the gills and mouth when fish are doing the process of breathing in water, in the digestive tract of fish, fiber is easier to accept than other types of microplastics because of differences in function and shape in the organs of fish that receive each type of food (Yona *et al*., 2020). The results of the study by Su *et al.* (2019) found fiber with a larger size (> 1 mm) in the digestive tract of fish. Rummel *et al.* (2016) also found fiber sizes of 150-3000 m in pelagic and demersal fish.

This is in accordance with the condition of the coastal area where the research is located, which is near community housing so that there are various activities that support the presence of this type of fiber microplastic content. Payangan and Puger beaches where the research is located are one of the tourist attractions that produce a lot of activities, one of which is swimming in the coastal area. This swimming activity can trigger microplastic contamination of fiber types because it comes from clothing threads. In addition, because the geographical location of the beach is close to community housing, it also allows the high activity of the surrounding community. The majority of the people around the coast also work as fishermen, thus allowing for the degradation of fishing gear.

Microplastic fragments can be sourced from pieces of plastic products with strong synthetic polymers and larger plastic fractures (Cole *et al*., 2011; Dewi *et al*., 2015). Fragment-type microplastic contamination can also be sourced from plastic bags, pieces of pvc pipes, food packaging and bottle caps (Azizah *et al*., 2020). This is also in accordance with the conditions of the research site, namely there are food stalls selling food such as fast food, snacks, and bottled water. The beach manager stated that the waste produced was not managed or transported by officers so that traders and the surrounding community threw their garbage on the beach and buried it in the beach sand. The number of microplastic fragments is influenced by several factors, such as the amount of plastic waste due to tourism and household activities such as the use of plastic bottles, mica packaging, and other objects with a strong plastic texture. Fragments are microplastics that are physically irregular in shape, usually come from pieces (Cole *et al.*, 2011; Hidalgo-Ruz *et al.*, 2012; Dai *et al.*, 2018), this type of microplastic fragment cannot be crushed using tweezers and tends to have an irregular shape with sharp edges.

Granule type microplastics can be sourced from beauty and hygiene products (Harahap *et al.*, 2019). Granule type microplastic is a primary type of microplastic so it is made in micro form in beauty and hygiene products. Granule type microplastic was only found in shellfish samples, namely clams 3 and 4. The existence of this type of granule microplastic was in accordance with the conditions of the research site which found many kinds of organic and inorganic waste including beauty products that were also wasted on the beach. The presence of microplastics in samples of marine fish and shellfish indicates that the Payangan and Puger Beach areas of Jember Regency where the study is located have been polluted by microplastics. This can endanger the survival of marine life and the people who consume it.

Filament type microplastics can be sourced from pieces of plastic that have a very thin layer in the form of sheets of low density (Dewi *et al.*, 2015; Di and Wang, 2018). This type of filament microplastic generally comes from the cut and degradation of plastic bags. This is in accordance with the research conditions, namely the coastal area is very dirty and a lot of garbage. The number of filament types is influenced by the habits of the local community in using plastic bags and other plastic packaging. The garbage comes from people who throw garbage around the beach and traders who are in the coastal area. The community stated that they bury their garbage in the sand and throw it around the beach because it is easier and more practical because their houses are close to the beach access. The beach manager also stated that the south coast is downstream from the coast of the city of Jember so that all the waste generated from upstream ends up or accumulates on the south coast. This causes the amount of waste to increase. The community also still does not have full awareness regarding the importance of maintaining environmental health.

Lusher *et al.* (2013), found about 36.5% microplastics in the digestive tract of 504 demersal and pelagic fish. Microplastics can have both physical and chemical effects on aquatic organisms. If ingested, microplastics may pass through the intestines or may be retained in the gastrointestinal tract (Browne *et al.*, 2008). Xiong *et al.* (2019) stated that if microplastic particles accumulate in large quantities in the intestines, they will have a harmful effect on fish and clog the digestive system which is carcinogenic and endocrine disorders (Derraik, 2002; Gregory, 2009; Oehlmann *et al.*, 2009; Ryan *et al.*, 2009; Browne, 2015). The smaller the microplastic particles, the greater the possibility of these microplastic particles being digested by aquatic organisms (Carlson *et al.*, 2017).

Based on the results of research conducted in the coastal area of Jember Regency, it is proven that marine fish and shells can be contaminated with microplastic contamination. Microplastics have physical, chemical, and biological impacts on aquatic biota that ingest them either directly or indirectly. Organisms that ingest indirectly can be through consumption of organisms that have been contaminated. This is dangerous for the survival of resources in the waters and the community as consumers of these resources.

## 4. Conclusion

Based on the research that has been done, it can be concluded that marine fish and shells in the coastal area of Jember Regency, Indonesia have been contaminated with microplastic contamination. The microplastic in each marine fish and shells sample has a different type. There were microplastic types of fiber, fragments, granules, and filaments in the shells sample, while in the marine fish samples, there were all these types except granules. The amount of pollution in the sea makes it a negative threat for marine products (fish, shellfish, or seafood). Microplastics can accumulate in the digestive tract of animals that eat plastic. The presence of microplastics in marine fish and shells can be dangerous for marine resources and the people who consume this aquatic biota, so attention needs to be given to immediately control efforts so that the impact is not wider and dangerous. The existence of garbage that is constantly increasing, the number of microplastics is also increasing and even more than the number of fish in the coastal.

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tics studied.

## Authors' Contributions

All authors conducted research, analyzed data, discussed results, and contributed to the final manuscript.

## Conflict of Interest

All authors declare that we have no conflicts of interest. Research carried out both conceptually and search field data do not get meaningful problems. The study was conducted in accordance with the plans that had been arranged before. Field data is easily obtained even though it takes time to get it.

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