Microplastics and the Impact of Plastic on Wildlife: A Literature Review

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Abstract. Microplastics (size <5 mm) have become an international attention since they have been discovered in wildlife and human gastro-intestinal tract, and might harm health. The objective of this paper is to review microplastics and analyze its possible impact on wildlife and seabird. Seabirds are upper-trophic level predators in marine ecosystems, feed on zooplankton, fish, and squid. Microplastics in seabirds have been reported in many countries, including the USA, Canada, Brazil, Japan, China, the Netherlands, and North Pacific region, involving albatrosses, petrels, storm-petrels, fulmars, cormorants, shearwaters, penguins, and many other seabird species. Microplastics were accidentally ingested because of their resemblance to the fish, plankton, or from ingestion of microplastics that already occurred inside fish food. Types of microplastics were pellet, fragment, film, fiber, foamed plastic and styrofoam. Microplastics might decrease feeding stimuli by producing a false sense of fullness, causing the bird to stop eating, resulting in malnutrition and death. Other harmful impact on birds are interrupting nutrient absorption, disrupting reproductive problems, and hindered growth and survival of chicks. Study on microplastics in Indonesia is in progress, by using Little-black cormorant to represent seabirds.

1. Introduction

The world plastics production has increased dramatically from 1.5 million tons in 1950 to 348 million metric tons in 2017 and is expected to continue to increase every year [1]. Plastics are widely used as a packaging material product because they are resistant to water, low density and relatively low price [2, 3]. Plastics have a low degradation ability in the tens to hundreds of years [2] resulting in increased waste. Plastics has become an international issue along with other global problems such as climate change, ocean acidification and biodiversity loss [4]. Eight million tons of plastic escaped from landfill systems which cause environmental pollution and ended into the sea [5]. Plastic waste in the oceans, also known as marine litter, is the solid material persistent manufactured that left or discarded in the marine and coastal environment [6].

Although plastic is highly persistent, this material can be degraded into smaller size. Plastic degradation is caused by biological processes, mechanical, and ultraviolet (UV) radiation [7, 8]. In this case, ultraviolet plays an important role in the degradation of plastic [9]. Degradation causes the plastic transform into smaller size or known as microplastics (size less than 5 μm) [10, 8, 9, 11].
Based on the source, microplastics can be divided into two types by sources: primary and secondary sources [12]. The primary source is the plastic that originated from pre-production plastic pellets, industrial abrasives, exfoliants, plastics used in tires, and other consumer products uses. Secondary microplastics in the environment are originated from the breakdown of larger plastic material, especially marine debris.

Plastics and microplastics are harmful to wildlife, especially marine life. Marine animals such as turtles, sea-birds, fish and whales have been injured or disabled as a result of plastic entanglement and swallowed [13]. In addition, the chemical compounds contained in plastic can cause blockage of the gastrointestinal tract, decreased enzyme secretion, decreased levels of steroid hormones and reproductive problems [14]. The types of microplastics, however, have not been defined clearly, and thus the objective of this paper is to review microplastics and analyze its possible impact on wildlife and seabird.

2. Methods

The data used in this paper was based on literature review of various from journals, theses, books and other literature related to plastics, microplastics and impact to the wildlife including seabirds. Among various journals that have been collected and read, 30 of them were specifically related to micro-plastics and the impact of plastic on wildlife.

3. Results

3.1. Characteristic, Type, Color and Source of Microplastics

The characteristic of microplastics has size less than 5 μm, microplastics do not have cellular or organic structures visible, and fibers should be equally thick [15]. Microplastics size has been established at the International Microplastics Workshop in Washington organized by the National Oceanographic and Atmospheric Agency (NOAA).

Based on the type, microplastics can be divided into fragments, pellets, fiber, plastic film, foamed plastic and styrofoam (Fig 1) [15]. Fragment is a secondary source of the results of the plastic pieces are degraded by ultraviolet, organisms, wind and waves. Fiber is a secondary source with an elongated shape that comes from fragmentation of monofilament nets, rope and synthetic fabrics. Pellets are the primary microplastics directly produced by the plant as a raw material for making plastic products. Plastic films are a secondary source with plastic sheets-shaped, while the styrofoam that is microplastics derived from styrofoam chips that we use in everyday life.

Microplastics can come from various sources, but generally comes from two sources: primary and secondary source [12, 16]. The primary source is pre-production plastic pellets usually used in health and personal care products (facial cleansers, moisturizers, shampoos, cosmetics and shaving products) also known as microbeads. After use, the product is washed up through the drains and finally reach the environment. Secondary microplastics are formed in the environment from the breakdown of larger plastic materials [12]. For example, losses of waste during collection of waste, from landfill sites and recycling facilities, material lost from fishing vessels and aquaculture facilities [16]. Plastic waste with the larger size transforms into microplastics by ultraviolet light, heat, organism, wind and wave [17].

Microplastics have various kind of colors such as transparent, white, red, orange, blue, black, green, brown, pink and yellow [15]. Microplastics colors potentially contributes to the possibility of being consumed by other animal for similar prey. The fish that prey on zooplankton may consume microplastics that resemble their prey such as white, yellow and brown [18].
3.2. Study and Impact of plastics and microplastic on seabird and marine life

Marine litters have negative impacts on marine ecosystems and marine life. There have been many reports of wildlife such as whales and seabirds die caused by plastic found in its body. Although plastic is not yet clear as the main cause of animal, it is possible to contribute to its death. Plastic waste in the oceans has killed 1 million sea birds, 100,000 sea mammals and countless fish every year [20]. When plastic floating in the ocean it can trap fish, turtles, mammals and birds and can even be swallowed.

Studies about plastics on marine wildlife have been reported in various countries. In Brazil, turtle was found died because of plastic. They ingested plastic in a form of ropes, nets, styrofoam and plastic bags [21]. Of the 371 autopsies performed on Leatherback turtle (*Dermochelys coriacea*), 37.2% of which were found plastic in its body. It mistook the floating plastic in the ocean as the jellyfish which is their main food [22]. In 2008 two sperm whales (*Physeter macrocephalus*) were found dead stranded in California and after an autopsy, plastic like fishnets and plastic pouches were found blocking its digestive system [23].

Plastics and microplastics research on birds, especially sea birds have been reported in various countries like USA, Canada, Brazil, Japan, China, the Netherlands, and North Pacific region. These studies started from 1969 by Kenyon & Kridler 1969 at 100 Laysan albatross carcasses were collected along beaches and reefs of Hawaii, 30% of which were found plastic. Research by Day of the marine bird in Alaska reported 15 of the 37 species of marine bird in Alaskan containing plastic particles [24]. Out of eighteen carcasses of seabirds in the Sub-Antarctic Heard Island, Australia dissected, only two birds, both are Antarctic Prions (*Pachyptila desolata*), contained in their digestive systems (proventriculus and gizzard) [25]. Plastic studies on birds were also reported in Procellariiforms Brazil. A total of 110 birds of 10 species were collected and 64.54% had plastic particles in their stomach. 890 plastic particles were found in the digestive system, the majority were of two main types: pellets (35.95%) and user of plastic (62.92%), which included plastic container fragments and monofilament line [26]. The species were observed among *Macronectes giganteus, Thalassarche melanophris, Puffinus Puffinus, Puffinus gravis, Daption capensis, Puffinus griseus, Fulmarus glacialis, Pachyptila belcheri and Procellaria aequinoctialis*. Research conducted by Tanaka *et al.* in Japan, 3 of
12 seabirds indicated digestive tract containing PBDE compounds, especially of type BDE209 and BDE183 which is also contained in the plastic compound [27]. There are 16 of 17 birds in China found that anthropogenic compounds are distinguished by colour and size [28]. In Indonesia study about plastics on seabird has never been done before, therefore we are now doing the study of plastic ingestion by seabird specifically on Little-black cormorant (Phalacrocorax sulcirostris). Seabirds use their sense of smell to find food. Plastics that have been in the ocean long enough can be a place the zooplankton to live. It makes it difficult for seabirds to distinguish whether the object is a plastic or their food [29]. The effects are physical disability, injury or even death. Chemicals contained in plastic also can harm the environment and living creatures. Plastic contains various chemicals during the manufacturing process such as (monomers and oligomers, bisphenol-A (BPA), phthalate plasticizers, flame retardants and antimicrobials) [21] which will be released into the environment. Therefore, plastic fragments that contain chemicals harmful if ingested by marine organisms.

Until now there has been no evidence of the direct link between the chemicals contained in marine litter and adverse effects for marine life. However, in experimental studies conducted by Oehlman et al. [30], which examines benzyl butyl phthalate (BBP) on a fish (Danio rerio) and BPA on a crustacean (copepod Arcartia A.) and an amphibian (Xenopus laevis) shows that BBP and BPA can affect the development and reproduction of the species in the water. Reproductive and developmental disturbances include alterations in the number of offspring produced and / or reduced hatching success, disruption of larval development and, in insects, delayed emergence. Reproductive problems can cause reduce the number of population of a species. Microplastics accumulated on animals potentially block the digestive system, causing a false sense of fullness and causing the bird to stop eating, resulting in malnutrition and death [18]. In addition, the ingested plastic also causes decreased feeding stimuli, gastrointestinal blockage, gastric enzymes secretion decreases and steroid hormones level decreases, leading to reproduction problems [23].

4. Conclusion

Microplastics is a plastic with a size less than 5 μm in the which are from primary and secondary source. Type of microplastics can be divided into fragments, pellets, fiber, plastic film, foamed plastic and styrofoam. The impact of the plastics and microplastics in seabirds are reproductive problems, malnutrition and death.

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