5. MALAYSIA

Summary of research topics: *A large proportion of peer-reviewed articles focus on the surveying and monitoring of both micro- and macro-plastics in various marine environs and with a geographic coverage of most of the country. Methodologies to monitoring and assessing were examined in few studies, considering the discrepancies seen across studies. Impacts posed by marine plastics were also explored, mainly in marine biota of commercial value and with a potential effect on human health. There have been some attempts at exploring the upstream origin of some marine plastic.*

Summary of understanding at national level: *Malaysia shows visible research efforts, with 36 literature reviews published, and has a good understanding of marine plastic pollution issues. Local research efforts are visible and active. The focus on surveying and monitoring provides valuable results for both abundance of macroplastic and microplastics. However, polymer types are generally not identified for microplastics, making any hypothesis of progress from macro- to micro-plastic difficult to be investigated. Ingestion by marine life is also explored but not transfer through the food chain, movement of plastic or plastic as a transport vector for its associated contaminants.*

Keywords/research fields: *National approach; solid waste; trade of plastic waste; research foci; marine environs; waste management; surveys and monitoring; methodology for the monitoring and assessment of marine litter; source differentiation; discharge from offshore infrastructures (including aquaculture); ecological and environmental impact; socio-economic impact; movement of plastics; social perceptions; plastics as transport vector; plastic additives; main players*

5.1 Context

5.1.1 National approach to plastic waste and its management

The Malaysian government aims to increase plastic recycling to 20% of plastic waste by 2020. It is putting in place a waste separation and collection system which has yet to be adopted and fully implemented throughout all states of Malaysia. Malaysia put a strong emphasis on reducing single-use plastic through a phased approach in its 2018 Roadmap Towards Zero Single-Use Plastics 2018–2030 (MESTECC, 2018). Presently, the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) is looking to establish the Malaysian Plastic Pact – an initiative to involve all stakeholders in combating plastic pollution and increase extended producer responsibility by 2022.

Based on estimates in Jambeck et al. (2015), Malaysia would have been the eighth worst country worldwide out of 192 coastal countries for generation of plastic waste in 2010. They estimated that Malaysia would have had a production of nearly one million tonnes of mismanaged plastic waste in 2010, of which 0.14 to 0.37 million tonnes may have entered the oceans. Policies regarding solid waste management have greatly evolved over the years into formal policies such as the National Strategic

Plan for Solid Waste Management 2005 and the Solid Waste and Public Cleansing Management Act 2007 (Act 672).

5.1.2 Plastics as a proportion of solid waste

In 2016, the municipal solid waste (MSW) for Malaysia was estimated at 13.7 million tonnes, and with a projection of reaching 18.2 million tonnes in 2030 and 23.7 million tonnes in 2050 (Kaza et al., 2018).

In Malaysia, plastic constitutes 24% of its total MSW (Aja and Al-Kayiem, 2014). In a major city such as Kuala Lumpur, plastics ranked second by composition for solid waste generated, at 11.45% after organic waste in 2000 (Saeed et al., 2009).

5.1.3 Illegal trade of plastic waste

Since China's 2018 ban on imported plastics, Malaysia appears to have received 195,000 tonnes of plastic waste imports from the USA alone between January to July 2018 (Greenpeace, 2018). Imports increased three-fold from 288,000 tonnes in early 2016 to 873,000 tonnes in end 2018. Lack of appropriate processing facilities to cope with the high influx of plastic waste imports resulted in large piles of illegally-burnt plastic remains or unclaimed plastic, particularly at Port Klang. There was also a sharp rise in illegal factories for the processing of plastic waste.

In October 2018, Ms. Yeo Bee Yin of MESTECC announced Malaysia's strong stand against illegal import of plastic waste. This was followed by an import ban on all plastic waste, scraps and pairings, except those issued with an Approved Permit (AP) issued by the National Solid Waste Management Department. The Government adopted a definition of plastic waste (which can only be disposed of) versus plastic scrap (which can be reused or recycled) under the 2018 Basel Convention Amendments. As of November 2019, 240 illegal factories had since been stopped, and plastic imports without an AP were sent back (pers. comms., Z.A. Tajuddin, Regional Enforcement Officer, Selangor Malaysia, 14 November 2019).

5.2 Research review of pollution from marine plastic

5.2.1 Research overview

This study includes 36 peer-reviewed studies for Malaysia. They cover a large geographical area as they extended to almost all 13 states, with the exception of the state of Perlis Indera Kayangan.

The marine plastic research identified covered ten research foci (Figure 1.2.5.1). Most of the research effort has been devoted to surveying and monitoring abundance of marine plastic debris (n=26), macroplastics found among macro-debris on the shoreline, and microplastics in various marine biota. The next most common research focus is on the ecological and environmental impacts posed by marine plastics (n=9), mostly through the study of the ingestion of plastics by marine biota. There are also clear attempts at understanding the socio-economic impacts of marine plastics (n=6), particularly on human health and food safety, through examinations of the presence of plastics in marine biota that are meant for human consumption. There are also attempts at understanding source differentiation (n=5), mostly through the identification of the origins of macroplastics based on their existing printed labels.

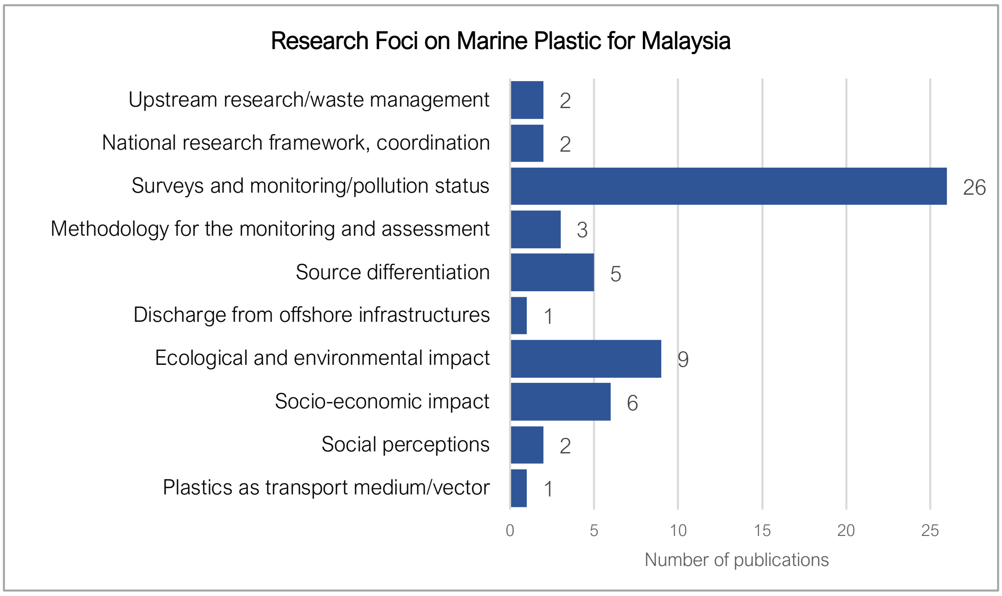

Figure 1.2.5.1. Research foci of marine plastic research conducted in Malaysia.

5.2.2 Types of research conducted

Types of plastics research foci

Microplastics studies appear to be of greater interest (n=20) to Malaysia's research community than macroplastics-only studies (n=14) and than both microplastics and macroplastics studies (n=2) (Figure 1.2.5.2). There has been an increase in the number of published studies on microplastics across various Malaysian institutions since 2016, which shows an increase in interest in the topic. The microplastics studies were mostly on the presence/absence of microplastics in marine biota and in the waters, while the macroplastics studies were mostly focused on the presence/absence of macroplastics on the shoreline as large marine debris.

In four studies, plastic-associated contaminants, particularly of plastic additives, were identified. In these studies, the microplastics of various polymer types examined revealed the identities of additives such as titanium dioxide, phthalocyanine, chromate yellow, hostaperm blue, hostasol green (Karami et al., 2017a, 2017b, 2019; Karbalaei et al., 2019).

Coverage of marine environs

Most of the research was conducted on the shoreline (n=18), followed by in marine biota (n=11) (Figure 1.2.5.3). Few studies have focused on either the sea surface or water column (n=5), or the seafloor (i.e. subsurface sediments) (n=1). Macroplastic prevalence has also been observed in riverine systems leading to the open ocean (Chukwuma et al., 2019) and on the sea surface (Estim and Sudirman, 2017).

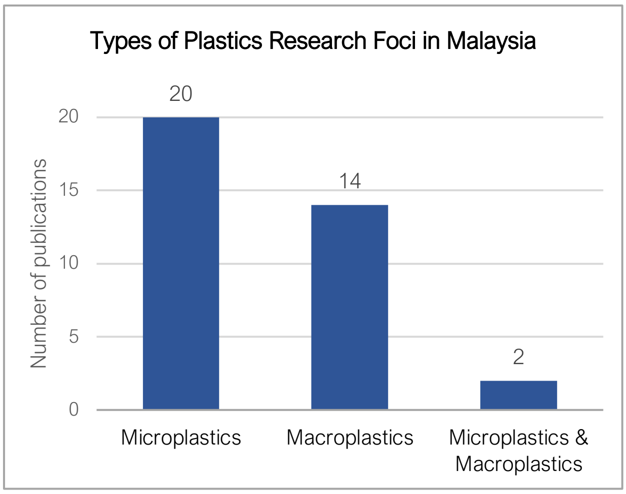

Figure 1.2.5.2. Distribution of marine micro-/macro-plastics researched in Malaysia.

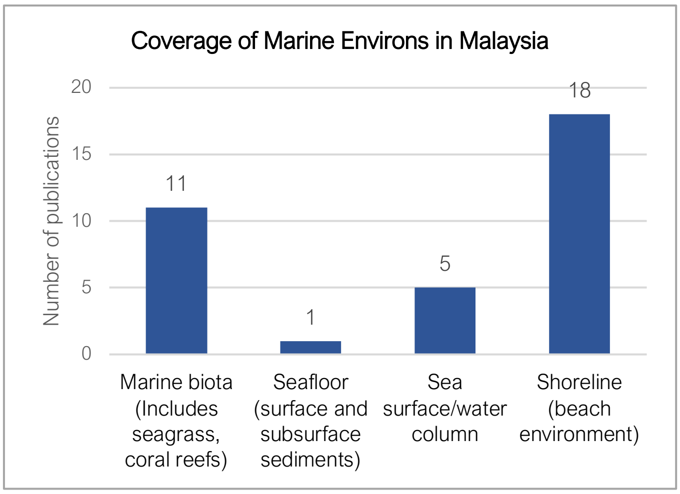

Figure 1.2.5.3. Distribution of marine environs researched in Malaysia.

5.2.3 Survey and monitoring

The great majority of published studies focused on surveying the extent of the presence of marine plastic in Malaysia.

Microplastics

Microplastics were found to be prevalent across a range of marine environs, especially marine biota and its surroundings. This includes microplastic contamination in wild fish, sea cucumber, bivalves and zooplankton (Amin et al., 2019; Ibrahim et al., 2016, 2017), as well as in commercial fish, sea cucumber (Karbalaei et al., 2019; Anuar et al., unpublished work; Ibrahim et al., 2017; Karami et al., 2018, 2017b) and in a sea turtle (Hocajo-Berná et al., unpublished work). Microplastics were also found in seafood-derived products of canned sardines and sprats (Karami et al., 2018). Apart from marine biota, microplastics were also found in abiotic environs including in the water column (Khalik et al., 2018), in the sediments of the open ocean (Matsuguma et al., 2017), on the shoreline sediments of sandy beaches (Estim and Sudirman, 2017; Noik and Tuah, 2015; Noik et al., 2015; Aris, 2012) and in mangrove ecosystems (Barasarathi et al., 2014).

In these studies, the microplastics studied were generally defined as being <5 mm, with the exception of 5 studies, mainly by Karami et al. (2017a, 2017b, 2018), Karbalaei et al. (2019) and Ibrahim et al. (2017). The former two authors defined microplastics as being within the 0.001–1 mm range, while Ibrahim et al. (2017) defined microplastics as being <1 mm. Microplastics have been further identified to its polymer types in most of the studies (90%). These studies reported common polymer types of PE and PP, as well as PET, PVC, PS, PA, LDPE, HDPE, PVA, as sampled from the natural environment. These studies were conducted by researchers from Universiti Putra Malaysia, University Malaysia Terengganu and Universiti Malaysia Sabah. Microplastics were also examined for their morphology and more than half (65%) of the studies reported finer structures of films and fibres among other structures of fragments, filaments, threadlikes, sphericals, pellets, foams and lines. Apart from microplastic contamination in the sea surface or water column, it appears that there is no clear consistency in the quantification of microplastics abundance across all marine environs studied. In the sea water or surface column studies, the microplastics of three studies were measured in units of particles per litre.

The studies on microplastic in marine biota used a variety of units, and reported quantities as particles with no other specifications, or as particles per individual, and also in density as gram per cm^3. In studies on the shoreline, microplastics were measured in quantity as number of particles or mean weight, and in density as gram per cm^3. In the sole seafloor study, microplastics were measured in units of particles per kg of dry sediment.

Macroplastics

Macroplastics were found to be the most common of all macro-debris, especially on the shoreline (Chee et al., 2019; Fauziah et al., 2019; Estim and Sudirman, 2017; Mobilik et al., 2017, 2016, 2015, 2014; Adnan et al., 2015; Fauziah et al., 2015; Noik and Tuah, 2015; Agamuthu et al., 2012; Khairunnisa et al., 2012; Razlan, 2011; Mobilik, 2008). All of these studies categorised macroplastics into functional types and were commonly of packaging, consumer products and fishing gears. However, polymer types do not appear to have been investigated.

5.2.4 Source differentiation and pathways

Source differentiation was attempted mainly on macroplastics found on the shoreline, through an examination of the country of origin on their product labels (Mobilik et al., 2014, 2015, 2017). Mobilik et al. (2016) examined marine litter on beaches located in proximity with shipping ports to explore whether shipping vessels docked were possible sources of plastic items found along the shoreline.

Praveena et al. (2018) studied microplastics in personal care and cosmetics products as a possible source for microplastics leaked into the natural environment with and without waste treatment.

Plastic-associated contaminants are also another concern when plastics can be transported as a vector along various environs. Plastic additives such as titanium dioxide, phthalocyanine, chromate yellow, hostaperm blue and hostasol green were found when examining microplastics of polymer types PE, PP, PET, PS, PVC, PAN, nylon-6, Polyisoprene/polystyrene (Karami et al., 2017a, 2017b, 2019; Karbalaei et al., 2019).

5.2.5 Movement of plastics, accumulation and hotspots

There is no published peer-reviewed study focusing solely on the movement, accumulation and hotspots of marine plastics. One study however, reported microplastic contamination in a remote mangrove ecosystem, suggesting that mangroves are potential accumulation zones for microplastics in the aquatic environment (Barasarathi et al., 2014).

5.2.6 Ecological and environmental impacts

Research efforts have focused on quantifying plastics ingested in various marine biota, through the dissection and analysis of marine biota including zooplankton sampled in the open ocean (Amin et al., 2019), and ark shell bivalves (Ibrahim et al., 2016). An opportunistic sampling in a green sea turtle off Tioman Island (Horcajo-Berná et al., unpublished work) was also performed, revealing the direct impact of plastic mass on the health of the animal. It was reported that plastic ingestion and mass accumulation had led to its starvation, which may have been its eventual cause of death.

Anuar et al. (unpublished work) in 2018 and Ibrahim et al. (2017) also quantified and compared the levels of microplastics ingested by wild and farmed marine biota, specifically sea cucumber and sea bass fish respectively. Although the two studies did not show common findings, it was interesting to note that the plastic ingestion rate in marine biota appears to be dependent on factors such as whether the wild animals are free to forage and if the caged animals are exposed to incoming tidal fluxes.

There were also studies looking into the quantification of plastic in commercial marine biota, such as in fish sold in fish markets (Karbalaei et al., 2019), in dried fish (Karami et al., 2017b) and in canned products of sardines and sprats (Karami et al., 2018).

5.2.7 ALDFG

There is no published peer-reviewed study on ALDFG. However, a large amount of ALDFGs were informally reported from the coral reefs of Tunku Abdul Rahman Park in Sabah. The ALDFGs were found by divers who frequent the area (The ASEAN Post, 2018: available https://theaseanpost.com/article/ghost-fishing-threatens-marine-life).

5.2.8 Social perceptions and socio-economic impacts

Two studies explored the social perceptions of the locals on marine plastic pollution responsibility. Agamuthu et al. (2012) interviewed the locals across the different states of Negeri Sembilan, Perak and Terengganu and explored their unwillingness to participate in beach clean-up activities or to pay for solid waste management services. The study found that despite their agreement on the importance of beach cleanliness, the locals were not willing to assist in beach cleaning or pay for beach management services. Mobilik (2008) however, found that the locals of Sarawak were willing to participate in beach clean-up activities and did acknowledge the issue of marine plastic pollution on the beaches.

The socio-economic impacts of marine plastic have mostly been considered indirectly, in the context of human health and in studies which quantify plastics in commercial seafood. Nine out of 11 species obtained from a local fish market in Selangor had ingested microplastic (Karbalaei et al., 2019). Four species of commercial dried fish that were eviscerated, revealed that evisceration does not necessarily eliminate the risk of microplastics intake by consumers (Karami et al., 2017b). Four out of 20 brands of canned sardines and sprats from 13 countries, including top brands from Malaysia, also contained microplastics (Karami et al., 2018). While the farmed sea bass fish (*Lates calcarifer*) showed lower microplastic contamination than its wild counterparts (Ibrahim et al., 2017), farmed sea cucumbers (*Holothuria scabra*) in a cage culture setting however, showed higher microplastic contamination than those in the wild (Anuar et al., unpublished work). One study also examined microplastic contamination in commercial salts obtained from different countries and reported that the microplastic contamination, though present, was too low to impose a human health risk on consumers (Karami et al., 2017a).

5.3 Main players in marine plastic research

Figure 1.2.5.4. Composition of research efforts seen in Malaysia.

Almost 90% of the research efforts in Malaysia was carried out by local researchers. There was one research study from each of the following additional countries: Nigeria, Japan and Iran.

There are at least three major research institutions with research teams at the forefront of marine plastics research in Malaysia. They are the University of Malaya (Fauziah S.H., Agamuthu P., Auta H.S, Emenike C.U.), the University of Sarawak (Mobilik J.M.), and the Universiti Malaysia Terengganu (Microplastic Research Interest Group comprising Khalik W.M.A.W.M, Ibrahim Y.S., Anuar S.T., Govindasamy S. and Baharuddin N.F.). Another group with an interest in plastic pollution had formed within the Universiti Malaysia Terengganu in late 2019. The group, Ocean Pollution and Ecotoxicology (OPEC: available https://www.facebook.com/Ocean-Pollution-Ecotoxicology-Research-Group-104974617658557/), comprises a multidisciplinary team of scientists with different expertise, including chemistry and biopolymer as well as physical oceanography, marine ecology and social sciences.

5.4 Summary of understanding

Like most ASEAN states hit by China’s 2018 plastic import ban and the current ‘plastic crisis’, Malaysia has deployed considerable efforts to decrease plastic waste, improve waste management and understand the status of pollution from marine plastics in its coastal and marine environment. With respect to the latter, a number of research foci have been explored, although most of these explorations are still at an early stage. The breadth of research has been limited, with emphasis placed either on coastline macroplastics or on microplastics in marine biota.

More than half of the articles published sought to quantify the presence and abundance of marine plastic debris. However, there were variations in the research methodologies, and the studies are therefore not often comparable. For instance, variations could be found in the sampling methodology used for macroplastics (via strip transect, quadrat, belt transect or others), in the sampling design (e.g. considerations of factors of temporal variations (such as selected monsoon seasons), and in the classification of macroplastics and microplastics studies.

The macroplastics sampled from the shoreline were categorised into various uses (e.g. packaging goods, consumer products and fishing gears), but the studies used often various classification systems. The microplastics were often categorised into various forms including those of films and fibres, but some studies used other definitions that are not well-standardised (i.e. filaments, thread-like, spheres, pellets, foams and lines). The definition of microplastics was also not standardised as being <5 mm; Some studies explored a smaller range (0.001–1 mm; <1 mm). Most of the microplastics studies further examined microplastic into its polymer types, and some studies identified plastic-associated contaminants, particularly additives. While there are these polymer-specific identifications, there have been no further studies conducted to explore specific polymer or associated contaminants toxicity impacts, their potential as a vector for contaminants and their sorption mechanisms.

The second most common category of research focus was that of ecological and environmental impacts. The studies primarily examined the ingestion of microplastics by marine life, especially organisms of socio-economic importance. No investigation on plastic transfer through the food chain has been found so far. Interestingly, there is no peer-reviewed article on the physical impact and the impact from ingestion of microplastics by wild animals (such as endangered migratory species like whales, sea turtles and seabirds). However, there were several news reports highlighting the impact of plastics on turtles and marine mammals, such as whales, dolphins and dugongs (New Straits Times, 2018: available https://www.nst.com.my/news/exclusive/2018/10/417648/plastic-thrown-oceans-causing-deaths-aquatic-mammals).

Geographically, the research covered all but one of the 13 states in Malaysia, with more attention on the bigger states.

While there is an apparent accumulation of plastic waste in the landfills and on open grounds, and while there is inadequate waste treatment and recycling, there were only a few published articles on the possible leakage of plastic into rivers and into the marine environments. Given their relevance to other sources and leakages, ALDFG would especially need further investigation as the fisheries sector is an important sub-sector in Malaysia. There are however, attempts at understanding the social perceptions that may be used to inform the development of effective waste management policy.

An important feature of Malaysia is that several research institutions are proving to have strong developing capacity. This includes existing clusters of academics (e.g. Microplastic Research Interest Group) and newly-formed plastic pollution interest groups (e.g. Ocean Pollution and Ecotoxicology of Universiti Malaysia Terengganu).