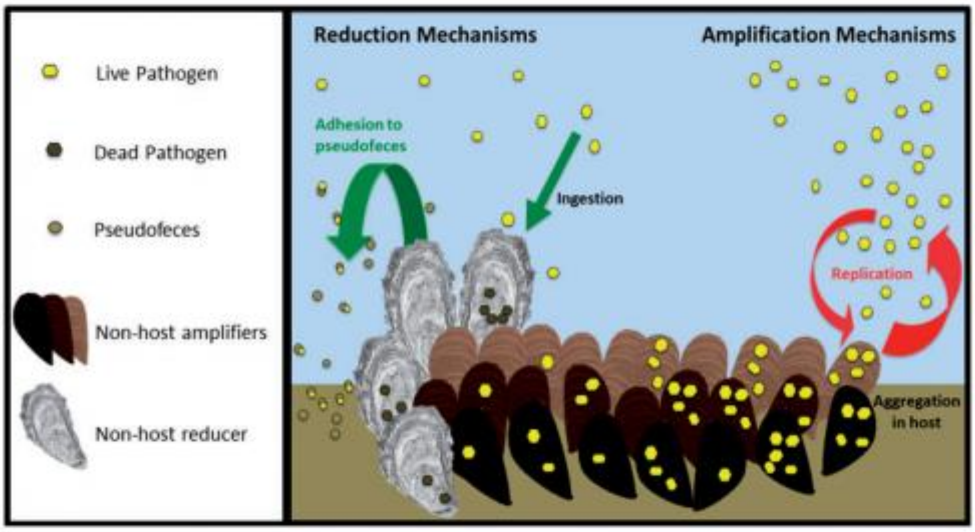
CHAPTER 2

LITERATURE REVIEW

2.1 Shellfish

Bivalves (*Phylum Mollusca)* such as cockles, mussels, oysters and clams feed by ingesting particles from the water surrounding using their gills, where selected particles were chosen according to size and density (Arapov et al., 2010). Blood cockles, also known as the arcid bivalve mollusc, or its scientific name *Anadara granosa*, is a crucial natural marine animal in Malaysia (Khalil, Yasin and Hwai, 2017). The natural populations and artificially seeded populations of this species were majorly done at Sungei Buloh and Kuala Selangor (Khalil et al., 2017). Another type of shellfish bivalve, *Corbicula leana,* or also known as mussels are famous in Sulawesi and Sumatera, Indonesia especially the lacustrine species of *Corbicula* (Pigneur et al., 2012). These two species also known as filter feeders where they captured particles and released as faeces and are discarded as pseudo-faeces (Alexander et al., 2008). Individual filter feeders can clarify particles from tens to hundreds of litres of water per day and they tend to consume planktonic species primarily such as dinoflagellates and diatoms (Burge et al., 2016). Other than that, bivalves also consume smaller organism such as bacteria, viruses and pathogens as well as particulate organic material (Arapov et al., 2010). Therefore, shellfish have the potential to accumulate or discard pathogens. Figure 2.1 shows pathogen filtration in bivalves.



Source: (Burge et al., 2016)

Figure 2.1: Filter feeders in altering pathogen through reduction and amplification

2.1.1 Filter feeding mechanism

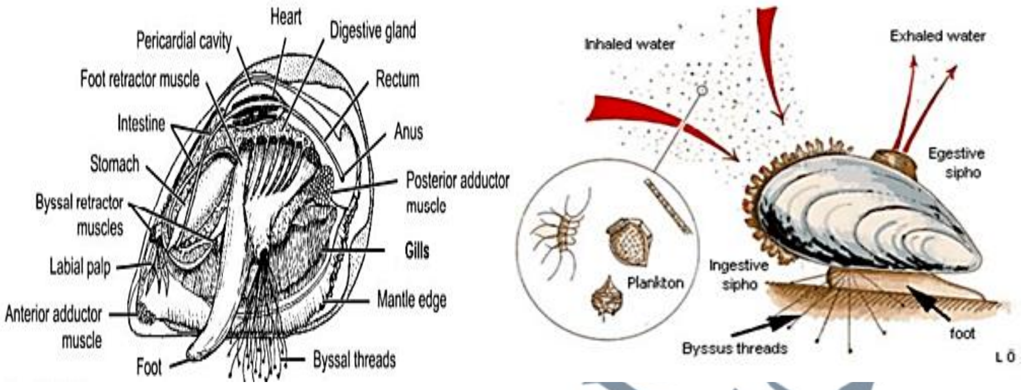
Generally, the aquaculture of shellfish is beneficial and harmless because it has filters feeders' mechanisms which relies on ambient primary production, able to enhance water clarity, degrade nutrients and phytoplankton concentrations and does not rely on other fish or food (Folke, 1989). Filter feeding shellfish can slow down phytoplankton biomass and alter the assemblage structure, and this mechanism also can obtain carbon from the microbial loop through ingestion of heterotrophic and mixotrophic bacteriovores (Lucas et al. 1987). In filter-feeding shellfish crustaceans, filtratory setae occur wherever small fragments particles are retained by a limb, and the conspicuous comb-like structures acts as filtering screens on the thoracic limbs (Buckholder, 2015). One special characteristic for filter feeding shellfish is that the process of filter feeding is through sieving, where various mesh size of the filter will ascertain the size of the ingested suspended food particles (Buckholder, 2015). Filter-feeding mechanisms of shellfish possess a various morphological diversity, including a huge range of different filter-feeding adaptations and mechanisms, which make them able to change different mode of feeding and powerful mechanochemical sensing of individual food particles with abundance specialized copepods (Buckholder, 2015). Therefore, the nature filter feeding mechanisms of the shellfish bivalves such as cockles and mussels make them naturally filter out any small fragments or debris that mistaken as food and chemical contaminants that sunk at the ocean floor due to their habitat living at the bottom of the sea. This potentially accumulate microplastics unintentionally in the gut of the shellfish through filter feeding mechanisms that would be beneficial to the author study in food safety.

2.1.1.1 Filter feeding mechanism of cockles

Particle retention in suspension-feeding bivalves such as cockles implies transport of particles from the current entering the intrafilamentary spaces to the current along the frontal surface of the filaments. In cockles with well-developed latero-frontal cirri, these have been associated with the function of straining the particles from the through-current and passing them on to the frontal ciliary tract. (Ward and Shumway, 2004). However, filter-feeders like cockles are selective feeders, where specific species will only filter and discard particulate matter of according to their appropriate size. For instance, *Cerastoderma edule* reject fragments in the range 2–12 µm selectively, *Venerupis corrugate* traps particles within a range from 5 to 13 µm, while *Hyriopsis cumingii* is high likely to filter phytoplankton with size ranging between 10 and 40 µm (Rong et al., 2021).

2.1.1.2 Filter feeding mechanism of mussels

Mussels, which also known as lamellibranchiate bivalves are capable to pump water over their gills and produce the water flow through the activity of the lateral cilia of the gills. Lateral cilia on gill filaments can actively control the pumping rate which flows into the inhalant siphon and then out of the exhalent siphon creating a water current (Wijsman and Smaal, 2017). The independent action of the lateral cilia and the difference musculature that control the shell gape, the exhaling siphon area and the interfilamentary distance of the gill can affect the effectiveness of the pumping rate (Cranford et.al., 2011). The blue mussel (Mytilus edulis) bivalve cannot differentiate between individual food particles (non-selective filter-feeders) as they feed by filtering fragments or molecules actively from the water surrounding (Cranford e.a., 2011), which passes through the mantle cavity via the frilled siphons (Figure 2.2). The gills traps all particles size ranging greater than 2 – 5 µm with 100% efficiency and the trapped fragments is then moved to the food grooves (ciliary tracts) on the gills and on to the labial palps (Figure 2.2). The labial palps acts to maintain the removal of materials continuously from the lamellar food tracts, either to be consumed as food or to be discarded or discharged as pseudofaeces (Wijmans and Smaal, 2017).



Source: (Wijsman and Smaal, 2017)

Figure 2.2: Filtering mechanism of blue mussel

2.1.2 Seafood consumption in Malaysia

According to Food and Agriculture Organization of the Union Nation (2020), the Malaysian conquered the highest seafood consumption per kapita globally where approximately 56 kg per annum make the total seafood production 1.99 million in 2016, of which divided 80 % from fisheries, while 20 % from aquaculture. In addition, Malaysia exports high amount of seafood products such as shrimp and sashimi tuna which makes the total profit gained USD 714.1 million in 2017. Traditionally, fresh aquatic animals are the most important fish product that was ingested but in current past years, source and demand for processed seafood products have greatly inclined. According to The Fisheries Development Authority of Malaysia (LKIM) in 2017, processed fishery products was the biggest export in Malaysia in the seafood industry as this sector reached more than RM1.2 billion. The Malaysian Investment Development Authority (MIDA) reported that the total exports of fish and other seafood including shellfish were greater than RM 2.5 billion per annum in Malaysia showing the growing of the fishery industry. The high statistics of fish consumption in Malaysia may become questionable towards Malaysian either they eat plastic-ingesting fish in high or adequate amount that may pose risks to health. The processed seafood and shellfish industry demand that have elevated in Malaysia recently may contribute to the ingestion of microplastics where the plastics from packaging may adsorbed to the processed fish and simultaneously enter food supply chain without realising. Yet, the study on plastics ingested by food crustaceans and shellfish in Malaysian is still not discovered and unknown by author.

2.2 Food safety in shellfish

The safety of the food must be secured from farm to plate, in which along the transportation of food from the farm directly to table need to be maintained in the supply chain (Manaf and Yusof, 2021). Seafood has high risk and have listed as the top foods transmitting disease. The food safety issues are crucial and statistically higher than 80% are reported for seafood poisoning related to scrombotoxin, biotoxins (ciguatoxin), or the consumption of raw shellfish bivalves (Huss, 2000). It is believed that the serious safety concerns related to the raw fish and shellfish intake due to the presence of microbiological (pathogenic bacteria, virus or parasites), chemical (heavy metals or biotoxins) and physical (microplastics) hazards (Huss, 2000). For instance, salmonellosis is an example of the foodborne diseases caused by *Salmonella* from shellfish which resulted 22.8 million cases approximately of diarrheal illness annually with total of 37,600 deaths in Southeast Asia (Van et al., 2012). Molluscan shellfish potentially concentrate hazards which come from small suspended particles including small plastic debris, concentrated heavy metals, and also small pathogenic microbes during filter feeding metabolic process. From the statistics, surveillance data suggests that seafood-borne diseases due to unknown causes, such as unknown hepatitis and certain Vibrio species sush as *V. parahaemolyticus*, *V. vulnificus*, non *V. cholera* that represent the major risk for people ingesting raw molluscan shellfish (Ahmed, 1992). On 1996 and 1997, in England and Wales, 17 general outbreaks of gastroenteritis were detected due to shellfish intake or consumption (Anon, 1998) where a total of 232 people got food poisoning. Five outbreaks reported were attributed with small round structured viruses (SRSV). Meanwhile, one outbreak was each associated for astrovirus, diarrhetic shellfish poisoning (DSP) and salmonella. Therefore, the safety concerns regarding biological, physical and chemical hazards through consumption of shellfish need to be seriously controlled by certified bodies by applying Good Manufacturing Practice (GMP), Good Hygiene Practice (GHP) as well as Hazards Analysis Critical Control Point (HACCP) programme to prevent contamination of various hazards on raw molluscan shellfish.

2.2.1 Microplastics as physical and chemical hazards in shellfish

Microplastics are always categorised into two types which are primary and secondary types. Primary microplastics that were originated from microbeads of personal products (Smith et al., 2018), were associated with the physical hazards that can unconsciously enter the digestive tract of humans by consuming shellfish bivalves. Physically, microplastics from the environment are prevalently found as fragments, pellets or fibres that comprised of various polymers (Hidalgo-Ruz, 2012). Secondary microplastics also associated with physical hazards which include microfibers from textiles, tyre dust and may be from larger plastic items that degrade into small plastic fragments namely microplastics due to weathering fragmentation (Duis and Coors, 2016). The term ‘microplastics’ is a special concern due to their small size which can be a potential physical hazard or harmful chemical hazards towards animals and human’s health (Peiru et al., 2020). Other than that, non-polymeric substances such as chemical additives or residual monomers can potentially be chemical hazards towards human health and the environment when the plastic polymers leach from the matrices (Teuten et al., 2009). Filter feeders may ingest all the leached particles unintentionally due to mistaken as food, hence, become accumulate in the tissues and become hazardous for human consumption. Several thousand additives are used which include in plastic products such as plasticizers, pigments, heat stabilizers, UV stabilizers and fillers (Rochman et al., 2013). These additives being intact with plastic potentially becomes microplastics after degraded and will be accumulated in the ocean such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene (HCB) (Rochman et al., 2013). The global distribution of physical and chemical from plastics in the marine ecosystem may affect the marine ecosystem as well as human health and become hazardous prior to consumption.

2.3 Microplastics

2.3.1 Source of microplastics

Plastics are large polymers that pose characteristics of lightweight, durable and resistant (Thompson et al., 2009). These benefits of plastics led to an enormous increase of plastic production in 60 years period. In 1950, 1.7

million metric tons have been produced compared to 335 million metric tons in 2017 in the world (PlasticEurope, 2018). Due to abundance of plastics consumption globally, plastics can be intentionally produced in small sizes specifically such as microbeads in beauty products or may lead to formation of microplastics by weathering process (Espiritu et al., 2019). In addition, there are plastics contaminants in every ocean globally (Provencher et al., 2010; Eriksen et al., 2014) and 90 % of marine plastics are microplastics (<5 µm) (Eriksen et al., 2014). Microplastics (<5 µm) and mesoplastics (5-10 µm) are significant issue because both are exposed readily for food uptake by many species of aquatic animals (Setala et al., 2014; Kuhn et al., 2015). Other than that, microplastics can be categorized into two sources: primary source and secondary source. Microbeads and small scrubbers as well as plastic pellet commonly used in personal products are described as primary source.

The primary source of microplastics have been engineered specifically to be used in cosmetics products mainly or as preproduction pellets (Lahens et al., 2018). Meanwhile, the secondary source of microplastics deprived from the degradation of bigger plastic polymers such as fibres, filaments and fragments (Wagner et al., 2014). More precisely, this source of microplastics originated from the larger plastic degradation majorly caused by light-degradation or mechanical action (Cooper and Corcoran, 2010; Derraik, 2002; Napper et al., 2015; Williams and Simmons, 1996). The list of common polymers found in microplastics is shown in Table 2.1.

Table 2.1: Common polymers with its density

Name	Typical density (g/cm^3)
Expanded Polystyrene (EPS)	0.02
Polypropylene (PP)	0.89
Polyethylene (PE)	0.96
Polystyrene (PS)	1.06
Polyamide /Nylon (PA)	1.14
Polycarbonate (PC)	1.21
Cellulose Acetate (CA)	1.30
Polyvinyl chloride (PVC)	1.39
Polyethylene terephthalate (PET)	1.39
Polytetrafluoroethylene (PTFE)	2.20

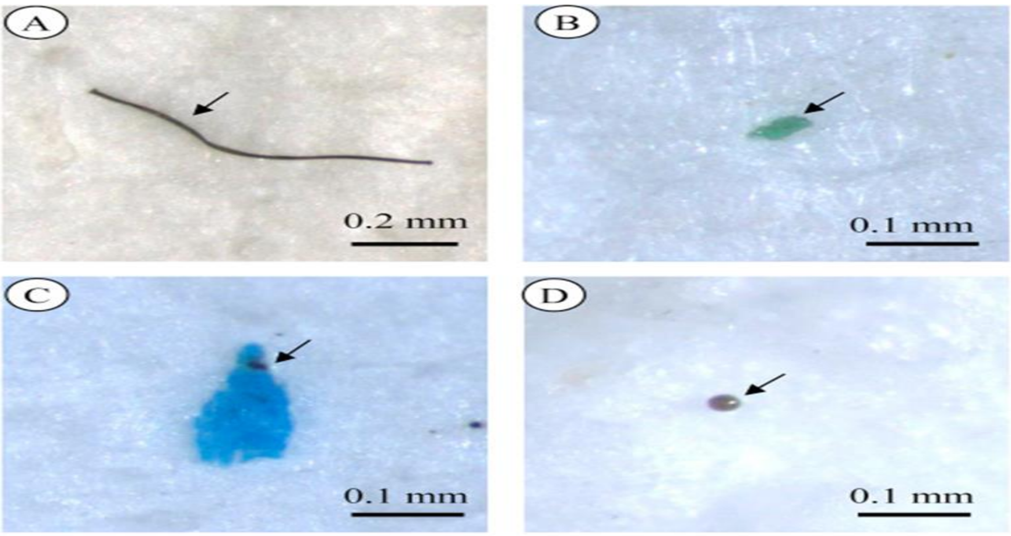
Source: (Fisher Scientific, n.d.)

2.3.2 Effects of microplastics

Since the mass production of plastics since 1940's, these polymers are widely used and become an integral part in modern daily life. Microplastic, as a product from degradation processes, such as auto-catalysis, thermo-oxidation, photo-oxidation and biological fragmentation ((Karami et al., 2016) has raised number of concerns as it can easily presence in various sizes in our environment and ecosystem ranging from 1 to 1000 µm in size (Karami et al., 2016). The toxic chemicals associated with the microplastics abundance in the marine ecosystem have become an alarming issue in Malaysia as the country is surrounded by South China Sea and Street of Malacca (West Coast Peninsular Malaysia), where people depend excessively on marine animals for sustainability of the food supply. In addition, Asia is one of the region least research regarding microplastic contamination and its effect towards environment, which is contrary with latest observations indicating that Asian rivers contribute most of the plastic waste into the sea worldwide (Lebreton et al., 2017). Furthermore, when plastic reaches the ocean, a fragment of plastic debris is submerged into the deep bottom of the sea, whereas the other fragment remains as floating fragmentations near the sea surface and accumulate gradually along the coastal belt (Gajahin et al., 2017). Consequently, different organisms in the coastal ecosystems are prone to ingest those micro-sized plastic particles. Sessile organisms such as mussels or cockles will be gradually affected by these environmental changes. Therefore, the impact of microplastic ingestion that may pose risks on marine organisms of different invertebrates or higher organisms including humans, are very significant given the potential for bioaccumulation and biomagnification of these contaminants through the food chain (Espiritu et al., 2019).

2.3.2.1 Effect of microplastics on marine environment

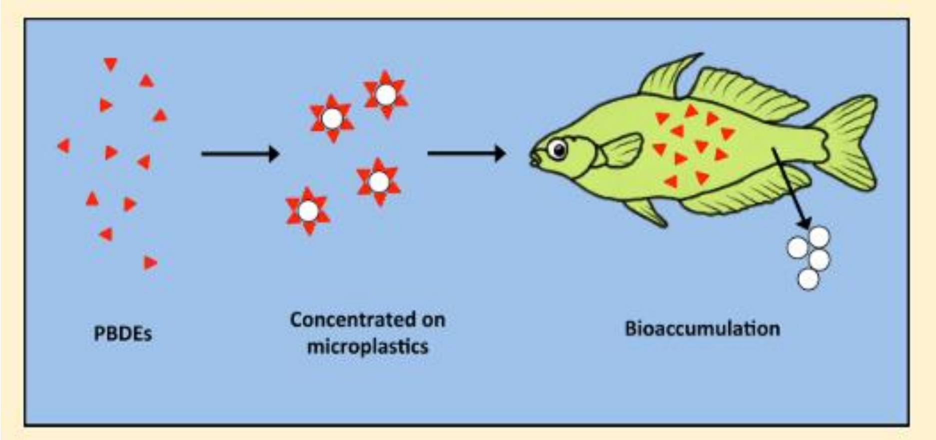
The toxic chemicals derived from the abundance of microplastic contaminants within aquatic food webs is an indispensable issue in Malaysia as the country is surrounded by South China Sea and Street of Malacca (West Coast Peninsular Malaysia), where people focus on marine animals for food sustainability. As reported by Mazurais et al. (2015), in European sea bass (*Dicenctrarchus labrax)* larvae, polyethylene microspheres did not give an impact towards Interleukins-1-beta (*1L-1b*) transcription level which is a key mediator for the inflammatory response or mediate communication between cells; or regulate growth rate but increase mortality rates at post-hatch of 14 and 20 days, probably due to blockage of the intestinal lumen. Therefore, various contaminants which diverse in marine environments lead to biomarker responses in fish or aquatic life as the impacts of associated chemical toxicants (Rudneva, 2013). In marine environments, microplastics can absorb many types of contaminants including polycyclic aromatic hydrocarbons (PAHs) which are widely segregated in aquatic and freshwater ecosystems (Karami et al., 2016). Acrylic fibres and polyester are the most predominant microplastics found in marine environment. Among the microplastics exist in the aquatic environments, phenanthrene (Phe) is one of the PAHs that widely distributed in contaminated sites and lead to toxicity in fish and humans (Karami et al., 2016). Figure 2.2 shows the image of microplastics isolated from the gut of the fish system under dissection light microscope.



Source: (Jabeen et al., 2017)

Figure 2.3: Images of microplastics isolated from the gut of various fish species from Taihu Lake, China under a dissecting microscope. The morphotype included were fibre (A), fragment (B, C) and pellet (D)

Other than that, it is reported by Wardrop et al. (2016) that ingestion of plastic debris can be proved on its presence in the intestinal tract of fish, as well as other aquatic animals like turtles and whales and has caused the dying of marine organisms through entanglement and blockage of the intestinal tract or gut. Different types of animals show different microplastics ingestion as it has been reported in deposit- and suspension-feeding sea cucumbers, deposit-feeding lungworms, detritivores amphipods and even zooplankton. In addition, the contamination of marine ecosystems associated with toxic pollutants are characterized by long-exposure of environmental movement, bioaccumulation and toxicity (Wardrop et al., 2016). The examples of organic pollutants adsorption to plastic debris include polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs) and perfluorinated surfactants (PFCs). Wardrop also reported that PBDE congeners can accumulate and enter the food chain in aquatic animals, thus the consumption of fish and shellfish has been strongly related to the rise levels of PBDEs in humans. Figure 2.3 shows the chemical pollutants (PBDEs) adsorbed to ingested microbeads then concentrated on microplastics which cause accumulation in fish.



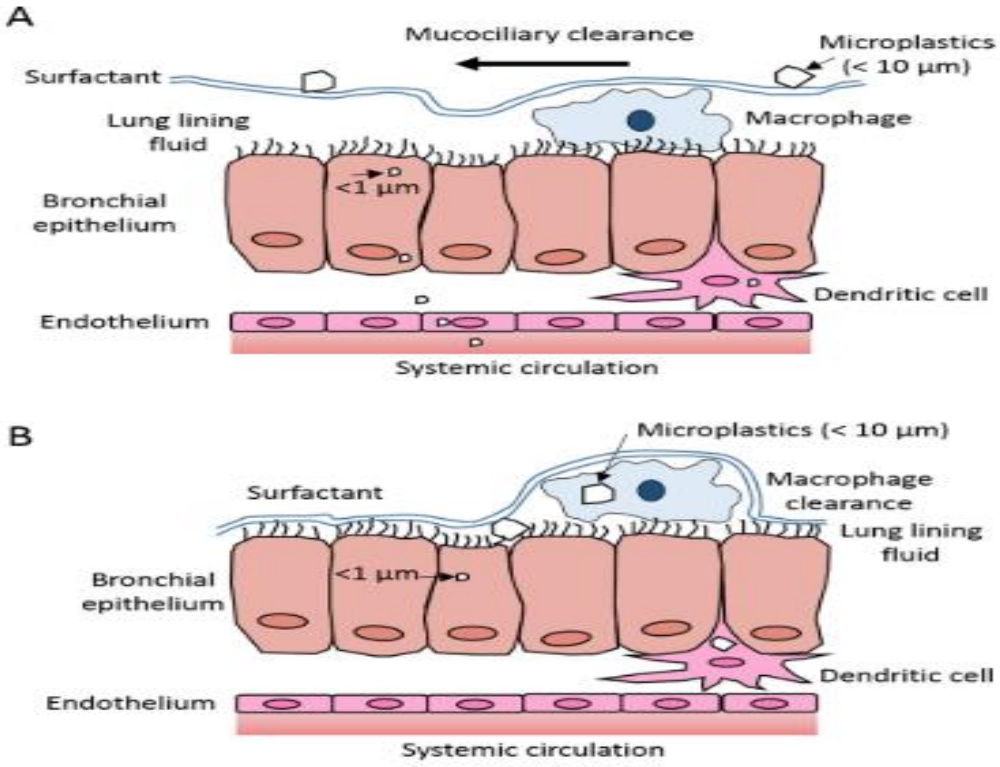
Source: Wardrop et al., (2016)

Figure 2.4: Chemicals sorbed to microplastics bioaccumulate on fish

2.3.2.2 Effect of microplastics on human health

Research indicates that chemicals such as hexachlorinated hexanes (HCHs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), triclosan, nonylphenols and heavy metals, among others accumulate on plastics (Mato et al., 2001). The chemicals may then transfer to the animal’s tissues after ingestion (Wardrop et al., 2016). The harmful effects of these synthetic polymers are various such as cellular necrosis and tissue lacerations in the gastrointestinal tract (Rochman et al., 2015), leading animals more vulnerable to stress (Rochman et al., 2013), and can cause liver malfunction due to toxicity (Rochman et al., 2013). Therefore, microplastics become a crucial issue because of the potential harmful and hazardous effects for people who eat fish and shellfish. This evidence shows the chemical contain in plastic residue could leach into our food system and remains in the supply chain even after processing such as washing and cooking. If inhaled or ingested, microplastics may biomagnified up and exert localized particle toxicity by triggering or boosting the immune response (Wright and Kelly, 2017).

Uptake of inhaled microplastics will rely on their wettability as it is possible that it will be blocked the airway and will be deposited in the lung lining fluid due to hydrophobicity and may lead to mucociliary clearance leading to exposure via the intestinal tract. Regarding physical effects of microplastics towards human health, the long exposure of microplastics could result in biological responses including oxidative stress, genotoxicity, inflammation, necrosis and apoptosis. If these conditions are continuous, the list of possible effects may happen including carcinogenesis, tissue damage and fibrosis (Wright and Kelly, 2017). The presence of microplastic accumulation were the pathway of chemicals to tissue and fluids. Therefore, the chemical additives and monomers can pose risks to human health including reproductive toxicity (e.g., bisphenol A [BPA]), carcinogenicity (e.g., butadiene and vinyl chloride) and mutagenicity (e.g., phenol and benzene). Other than that, phthalates also one of the most harmful chemical additives derived from plastics that able to attach with molecular targets in the body then disturbing hormones regulations. Following that, microplastics may resulting inflammation or leach hydrophobic organic contaminants (HOC) on which could to oxidative stress (Wright and Kelly, 2017). Figure 2.4 shows the potential microplastic (0.1 > 10 µm) uptake and clearance mechanisms in the lung. (A) The chance of microplastic displacement by the lung lining fluid (surfactant and mucus) is reduced in the upper airway, where the lining is thick (central lung) meanwhile, (B) if the aerodynamic diameter of a microplastic permits deposition deeper in the lung, it may penetrate the thinner lung lining fluid and contact the epithelium, translocating via diffusion or active cellular uptake impacting the immune system.



Source: Ruge et al. (2013)

Figure 2.5: Potential microplastic (0.1 > 10 µm) uptake and clearance mechanisms in the lung.

There are also key routes on how microplastic end up in the human body which are either by inhalation by airborne microplastics particles, ingestion of food that have contaminated by microplastics originated from synthetic fibres from textiles and polluted atmosphere, and by skin contact where nano-particles can penetrate directly or indirectly through skin wound or weakened skin barrier (Yee et al., 2021). Tiny particles such as nano-plastics may interact with nutrient in the body such as lipids, carbohydrates, proteins and water, causing to the formation of coronated nano-plastic for absorption. The three key routes of microplastics invading human body were portrayed as in Figure 2.5.

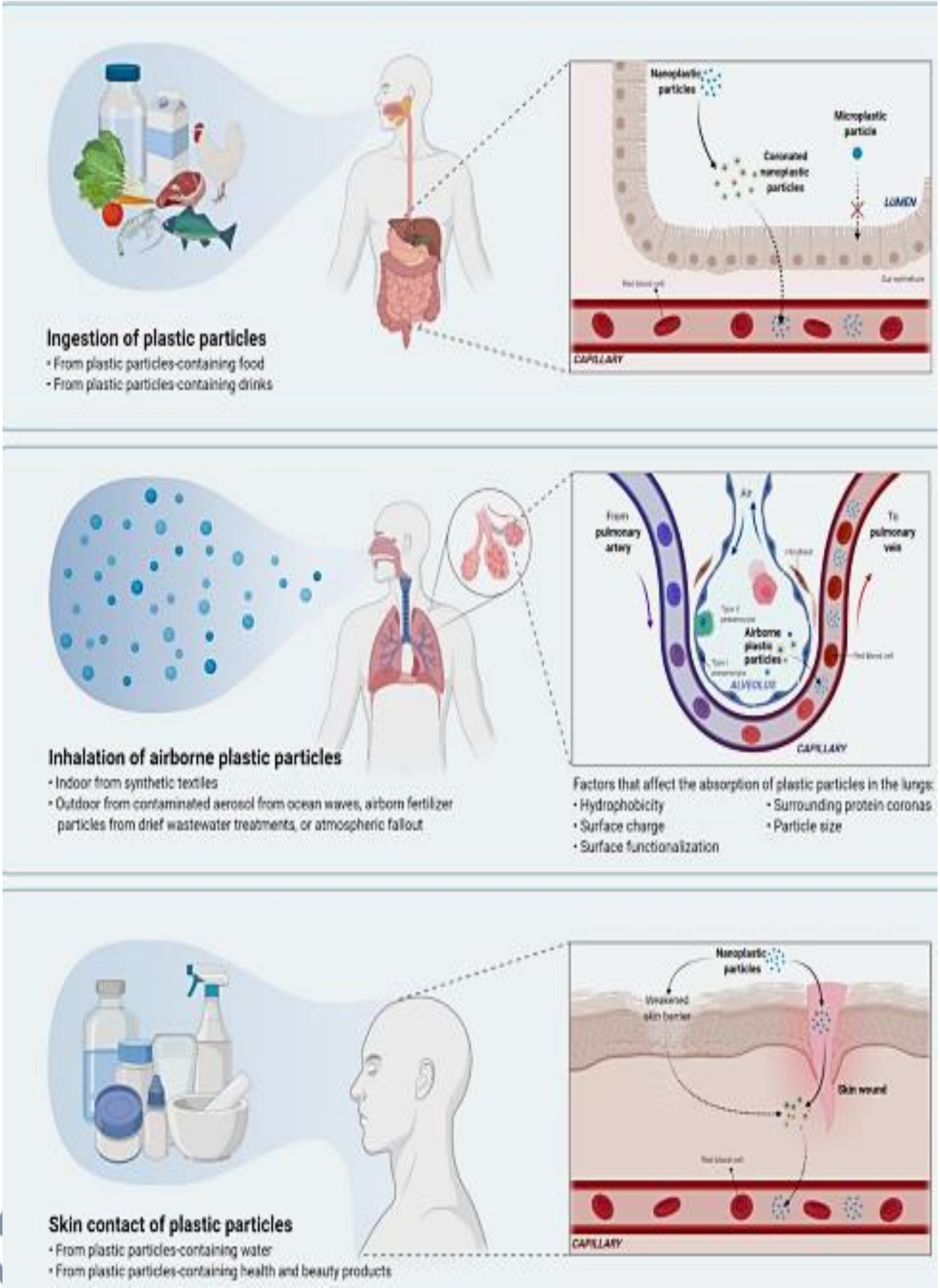


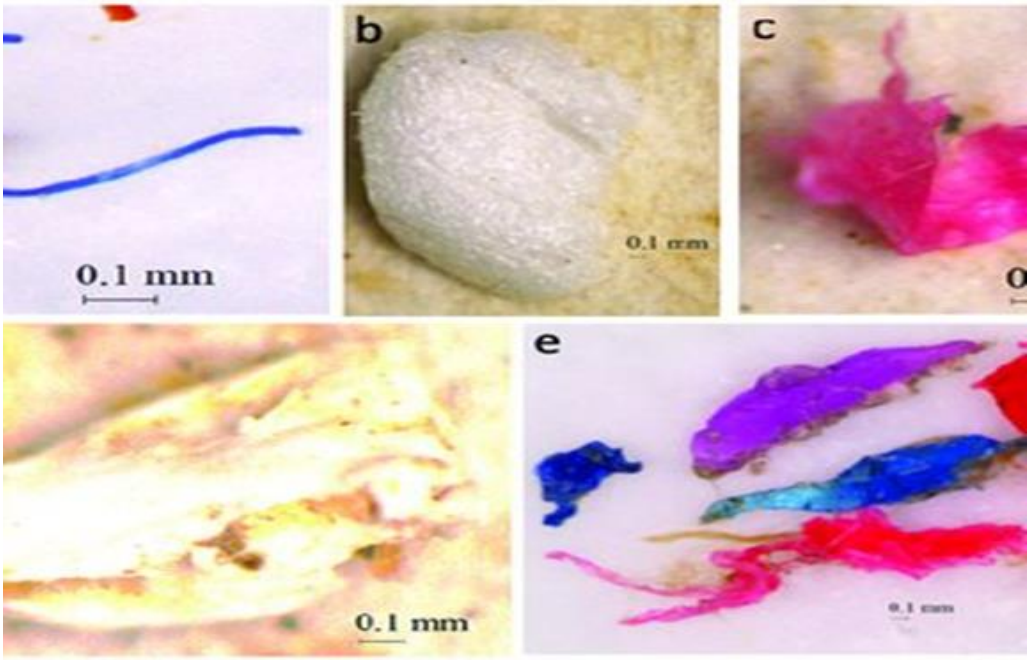
Figure 2.6: Key routes of microplastics enter the human body (Yee et al., 2021)

2.3.3 Strategic sites for plastic contamination

Since the South China Sea is one of the busiest trading routes, plastic fragments may be deposited from the shipping sector. Moreover, these sites were also exposed to anthropogenic activities through recreational attractions such as swimming, picnicking and fishing activities, including fish grading, cleaning, and sorting, as well as activities involving fixing of the fishing gears (net and boats) (Fauziah, Liyana, & Agamuthu, 2015). The shores are also populated with residential area. Due to heavy burden of anthropogenic activities, plastic contamination is possibly higher in these strategic sites. In addition, plastic fragments that deposited in the coastal water occurs through the tidal abrasion of waves, trading and fishing activities, which transfer waste materials from one region to another other than the weakness of solid waste management systems as the major constituent of microplastics (Fauziah et al., 2015). Malaysia’s coastal areas are portrayed by a rich diversity of environmental, cultural, natural and socioeconomic resources which also known as the country’s most valuable assets. However, as a result of marine debris and anthropogenic activities at the coastal area, the quality has deteriorated. Although winds and currents may be responsible and the minor factor for the waste disposal from outside on the coastal areas, over 50 % of the plastic fragments is left behind by bathers and vacationers (Kaur and Jaabi, 2017). Along with human irresponsible action and anthropogenic activities, plastic leakages and degradation are seen as one of the major factors leading to the death of wild live and water pollution, and a threat to food security in human ecosystem (Kaur and Jaabi, 2017). Despite this, studies on fisheries and microplastics contamination in Malaysia are lacking especially in fish and shellfish ingestion of microplastics located at west coast Peninsular Malaysia. Since cockles and mussels are widely collected in Sebatu, Melaka and Tanjong Karang, Selangor, therefore, the sample will be obtained from these two strategic sites to screen and identify the presence of microplastic on both shellfishes that may beneficial towards author knowledge as well as food industry, food safety and economy.

2.3.4 Microplastics on shellfish

Shellfish such as mussels, cockles, clam, oyster and some shrimps are filter feeders, aquatic marine bivalve that can be found in beaches comprising mixture of sand and mud. Filter feeders can be defined as a group of suspension feeding animals that feed by capturing suspended sediments and small food fragments from ocean, typically by allowing the water pass through over a specialized filtering structure. Following that, filter feeding species are biofilters and can reduce disease risk to human and wildlife naturally via degradation and release of pathogens in pseudofaeces (Burge et al., n.d.). Therefore, filter feeders such as mussels, oysters and some shrimps are mainly investigated for microplastic uptake. Plastics have been discovered in marine species commonly ingested by humans, including shrimp (Setala et al., 2014), also bivalves, such as cockles, oysters and mussels (Von Moos, Burkhardt-Holm, and Köhler, 2012) and fish from different trophic levels (Lise, Bråte, Eidsvoll, Steindal, and Thomas, 2016). In addition, microplastics are ingested by bivalves either directly or indirectly when they consumed lower trophic levels that have initially ingested microplastics (Nelms, Galloway, Godley, Jarvis, and Lindeque, 2018). The most dominant morphology reported in bivalve is microplastics fibres (Lundebye et al., 2022). For instance, about 80% of microplastics fibres reported in mussels (*Mytilus edulis*, *Perna viridis)* from China (Qu et al., 2018), 99 % in razor clams (*Siliqua patula)* and Pacific oyster *(Crassostrea gigas)* originated from Oregon, USA (Baechler et al., 2020) and also 90% accounted in Manila clams (*V.philippinarum)* from British Columbia (Davidson and Dudas, 2016). On the other hand, the particles could also be swallowed together with the preys (Sarijan, Azman, Said, and Lee, 2019). Microplastics are also known as a potential transporter to carry chemical contaminants and able to pass through the organisms in the food (Anbumani and Kakkar, 2018). Microplastics were discovered from the soft tissues of both species. At time of human consumption, van Cauwenberghe and Janssen (2014) reported a type of blue mussels, *Mytilus edulis* contains on average 0.38 ± 0.07 particles g^{-1} (wet weight), while a plastic load of 0.47 ± 0.16 particles g^{-1} fresh weight basis, was detected in oyster *(Crassostri gigas).* As a result, the dietary intake for European shellfish consumers approximately 11,000 microplastics per annum (van Cauwenberghe et al., 2014) through the eating of shellfish. This shows pollution of microplastic through ingestion of shellfish such as mussels and cockles could present at any point in our food chain. Figure 2.6 shows the gut of diverse species of fish that have been polluted with microplastics contaminants.



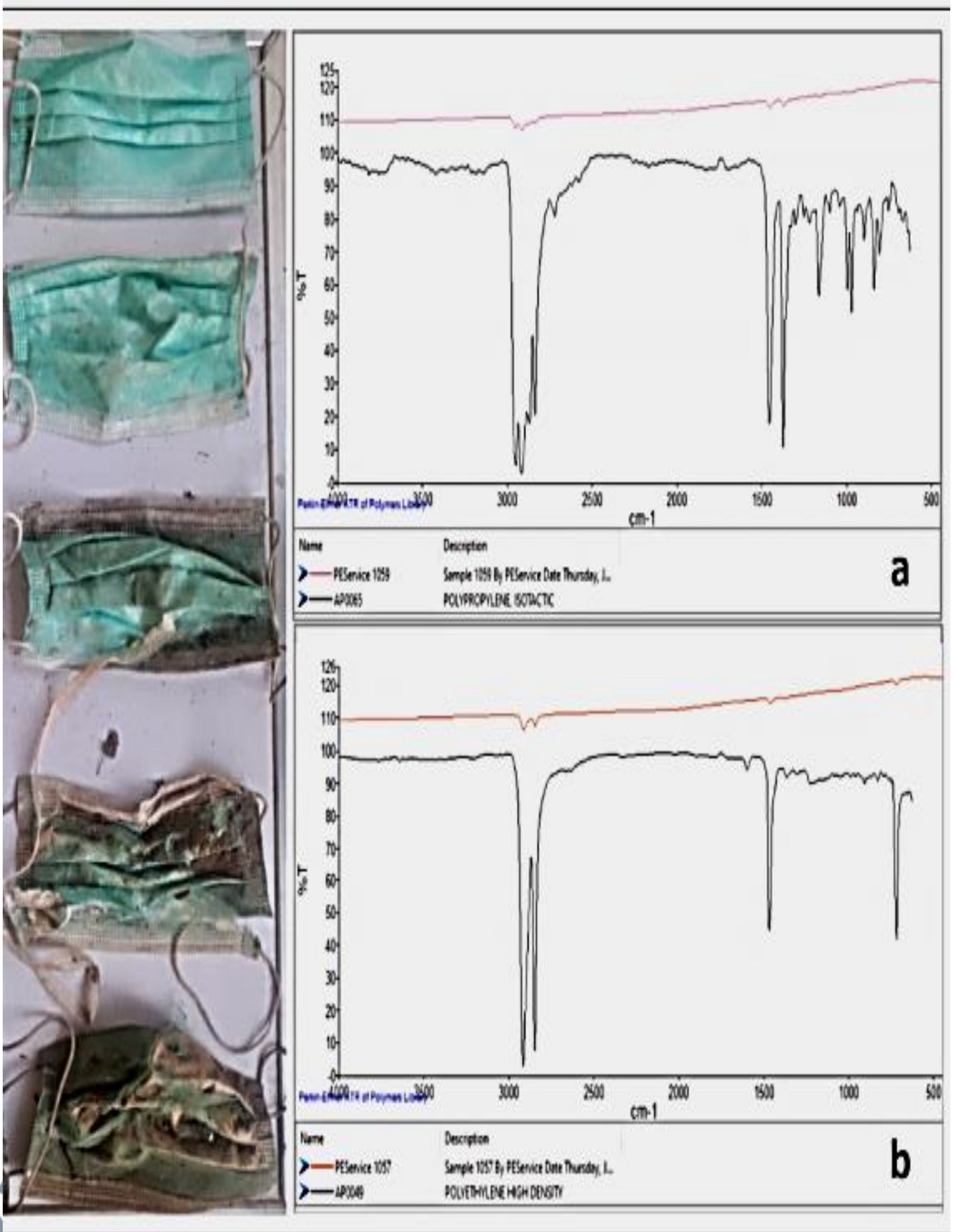
Source: (Sarijan et al., 2019b)

Figure 2.7: Microplastics extracted from the gut of diverse species of fish in the Skudai River, Johor, which were (a) fibre, (b) foam, (c) film, (d) fragment, and colourful film and (e) fragment.

2.3.5 Microplastics occurrence during pandemic

Microplastics in marine ecosystem may be originated from solid waste and also derived from domestic sewage (Ziajahromiet al., 2020). Somehow, with regard to the pandemic of Covid 19 which was detected at the end of 2019 (Xu and Li, 2020), World Health Organization (2020) has advocated people to wear disposable surgical face masks in order to decelerate the spread of Covid 19 from one person to another. It is estimated that approximately around 89 million of medical face masks are needed monthly to combat the spread of Covid 19 (WHO, 2020). In another country, China also has inclined its production of face masks up to 14.8 million by February 2020 (Xinhuanet, 2020). In Japan, more than 600 million masks orders have been served per month by April 2020 (METI, 2020). As disposable surgical face masks are originated from polymeric substances of plastics such as polystyrene, polypropylene, polyethylene, polyacrylonitrile, polycarbonate or polyester (Potluri and Needham, 2005), this demand of face masks production has introduced polymeric substances to the environment as these polymers will enter aquatic and terrestrial surroundings leading to microplastics contaminants through plastics degradation. Figure 2.7

shows the polymer plastics materials that made of two layers of fibres (outer and inner) and also added with the middle layer for the medical purpose to filter out more than 99 % of bacteria (Aragaw, 2020).



Source: Fadare et al. (2020)

Figure 2.8: The degradation stages of the face masks in the environment and the FTIR spectrum at the outer layer (a) and the inner layer (b) of the degrading fibres.