KFAS
مؤسسة الكويت للتقدم العلمي
Kuwait Foundation for the Advancement of Sciences

Marine Litter in the Arabian Gulf with a Specific Focus on the State of Kuwait:

Current Knowledge, Research Gaps & Recommendations

A white paper on the role of KFAS in addressing challenges & identifying knowledge gaps

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Cefas

KISR
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الملخص التنفيذي

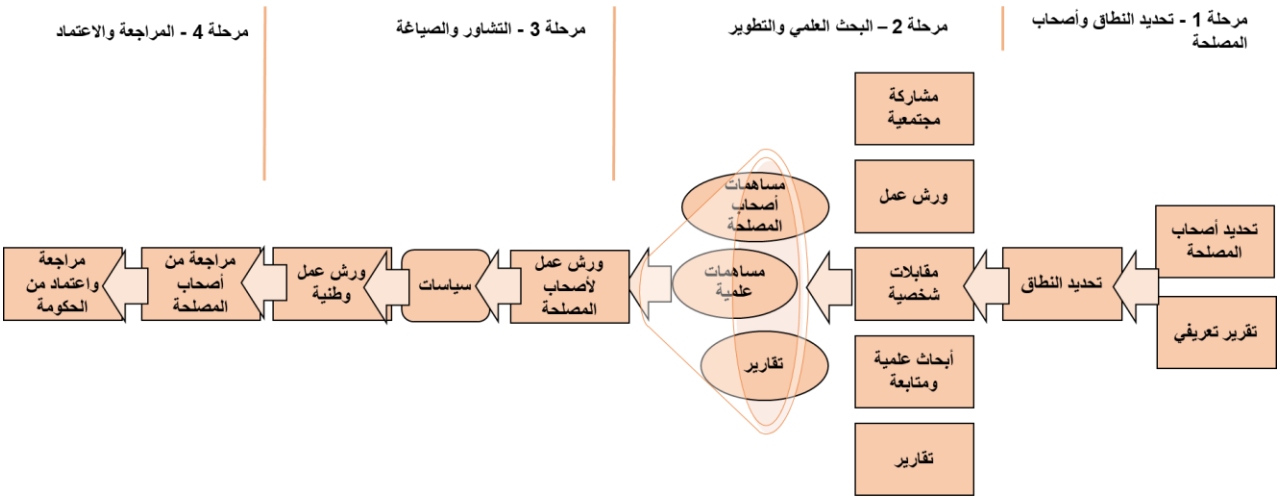
أصبح تأثير النفايات البحرية من المسلمات والمتعارف عليه كأحد أبرز العقبات للحصول على بيئة آمنة، إضافة إلى الملوثات الأخرى الكثيرة، هذا إلى جانب المخاوف المتزايدة الناجمة عن تأثير التغيير المناخي. وقد مَثّل موضوع النفايات البحرية خلال السنوات القليلة الماضية فجوة معرفية في مجال اتخاذ القرارات ورسم السياسات الخاصة بالبيئة البحرية.

كما تجدر الإشارة إلى أن موضوع دراسة النفايات البحرية مرتبط ارتباط وثيق بمصادر النفايات الصلبة من البيئة البرية كمصدر رئيسي لها. ممّا يُحتّم دراسة مصادر هذه النفايات وتحديد القطاعات المختلفة لمعالجتها بشكل صحيح ولحل مشكلة بيئية تشكل خطر على منطقة الخليج العربي، والتي حيث يشكل تزايد القوى الاقتصادية حملا إضافيا على البيئة البحرية والساحلية. وبالرجوع إلى البيانات القليلة المنشورة فيما يخص النفايات البحرية نجد بأنها تشكل عائق للرخاء الاجتماعي-الاقتصادي والبيئي في المنطقة.

وعليه تم إعداد هذه الوثيقة كنتاج للعصف الذهني ومخرجات الورشة التي تم تنظيمها من قبل مؤسسة الكويت للتقدم العلمي في الفترة ما بين 9-11 نوفمبر 2020 بعنوان النفايات البحرية، وذلك بغية دراسة مسألة النفايات البحرية في منطقة الخليج وبالأخص في دولة الكويت. حيث تم تشكيل لجنة من الجهات المختصة على مستوى الدولة كمعهد الكويت للأبحاث العلمية، جامعة الكويت، والهيئة العامة للبيئة ومؤسسة الكويت للتقدم العلمي كما تم الاستعانة بمركز علوم البيئة والثروة السمكية والاستزراع السمكي (المملكة المتحدة)،لإعداد وتقديم إطار عام للعمل المستقبلي والذي يعد " خارطة طريق مقترحة للدولة" للمتابعة الحثيثة في كل ما يتعلق بالنفايات البحرية بالدولة والتي ترتكز على خمسة نقاط رئيسية متمثلة بالتالي ذكره: الحوكمة، الخطة التنفيذية، البحث العلمي والمتابعة، التوعية والتعليم، وأخيرا الأطر القانونية. كما تبينت الوثيقة الحاجة للعمل على دراسات مسح شامل والتي تم اقتراحها في طي هذه الوثيقة.

فيما يخص نطاق الحوكمة فمن المقترح أن يتم إنشاء كيان تقني لإدارة المهام المتعلقة بالنفاية البحرية مع تدشين فريق مختص للدعم الفني. كما وجب التنويه بأن من أهم العناصر المستقبلية للخطة هي مسألة البحث والتطوير العلمي، وعليه وجب وضع خطة علمية تحوي أهداف بحثية، أطر تنفيذية، خطة زمنية وآلية للتنفيذ. متضمنة على مراحل أساسية تتلخص على النحو الاتي:

- تحديد النطاق وأصحاب المصلحة.
- جمع البيانات بما فيها الخيارات المتعددة للسياسات العامة للنفاية البحرية ومقابلة المعنيين بالموضوع.
- تنظيم ورش عمل ولجان فنية مختصة
- الأخذ بعين الاعتبار التوصيات الناتجة من ورشة العمل



كما وجب الحرص على تطبيق التوصيات العلمية الناجمة من الدراسات المتاحة والاخذ بعين الاعتبار سد الثغرات البحثية كذلك للنفايات البحرية متضمنة دراسات المناطق البحرية ذات الحساسية العالية كالشعب المرجانية والنباتات البحرية. كل هذا دون اغفال دور التوعية المجتمعية والتي يمكن ان ينجم منها كذلك حملات متعددة للمواطنين والمقيمين ودعم برامج علوم المواطن ومساهماتهم في المراقبة وجمع البيانات.

Executive Summary

The impact of marine litter is a widely known issue that has been recognised as one of the main growing obstacles hindering a safe environment. This matter combined with the over growing concerns of climate change impact and pollution, has presented a gap in knowledge when it comes to policy and decision making in recent years for a safe and healthy marine environment.

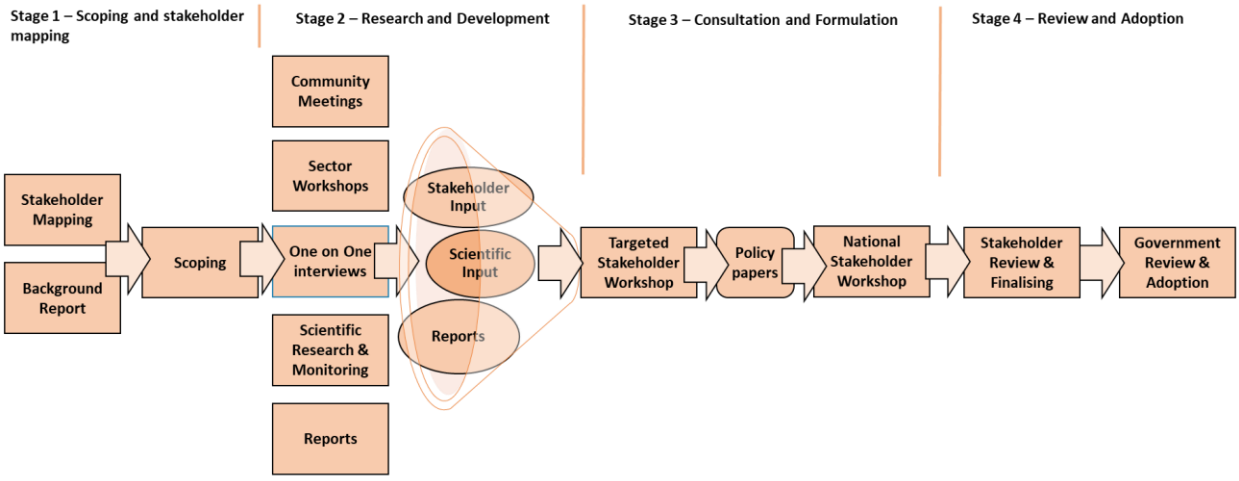
Marine litter is also a matter that is well tied with common waste sources and studies tackling various solid waste generation sources of terrestrial nature. Waste generation, across multiple sectors, is a known issue in the Arabian Gulf where rapid economic growth has placed additional stress on infrastructure and coastal communities. While data is limited to such matters, scant studies have been conducted in the Arabian Gulf region which demonstrate that marine litter is posing a clear and growing threat to the environmental and socioeconomic prosperity of the region.

This White Paper (an output from the Marine Litter workshop organised by the Kuwait Foundation for the Advancement of Science from the 9th to the 11th of November 2020), is formulated to dissect and understand the issue of marine litter within the Arabian Gulf; in particular, focusing on the State of Kuwait. A committee was formulated with members from local and international parties, namely the Centre for Environment, Fisheries and Aquaculture Science (Cefas - UK), the Kuwait Institute for Scientific Research (KISR), Kuwait Foundation for the Advancement of Sciences (KFAS), Kuwait University (KU) and Kuwait Environment Public Authority (KEPA) to compile a framework for establishing and implementing a Kuwait focused "Marine Litter Action Plan" is proposed. This framework stems from gathered experiences and published results which revolves around five main pillars that are interconnected to the current policies: Governance, action plan, research and monitoring, awareness and education, and legal framework.

A clear requirement for regionally coordinated baseline surveys to gain a better understanding of the composition and main sources of marine litter in the region, is also suggested.

As for the governance, it is foreseen that establishing both an entity for regional response and a taskforce term of reference are essential steps in the future roadmap. On the other hand, and pertaining future research prospects, it is quite elementary to develop an Action Plan with objectives, actions, time frames and implementation mechanisms with relevant stakeholders. Such key stages include:

- Scoping and Stakeholder mapping
- Data gathering (community/stakeholder meetings, research and development requirements)
- Consultation and Formulation (policy options, national committee workshops)
- Review and Adoption



Furthermore, it is essential on the future research front to implement studies on the impact of accumulated litter, including fishing gear, on coral reef communities and other sensitive habitats (e.g., sea grass beds and mangrove forests). In addition, there should be a future focus on the Awareness and Educational aspects that will raise the public's awareness and engagement. These could also be beneficial to the monitoring of marine litter accumulation on various beaches and coastal areas (promoting citizen science groups).

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Abbreviations

EU	European Union
GCC	Gulf Council Countries
KFAS	Kuwait Foundation for the Advancement of Sciences
MP	Microplastics
PE	Polyethylene
PET	Polyethylene Terephthalate
PSW	Plastic Solid Waste
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
ROPME	Regional Organisation for Protection of the Marine Environment
WM	Waste Management
UAE	United Arab Emirates
UNEP	United Nations Environment Programme
ME	Middle East
MSW	Municipal Solid Waste
SW	Solid Waste

Purpose and Scope of this White Paper

This white paper was prepared for the Kuwait Foundation for the Advancement of Sciences (KFAS) as an output from a series of virtual Marine Litter workshops from the 9th to the 11th of November 2020 (Appendix A). The white paper puts together several recommendations that were extracted from meetings with experts in this subject area whilst conducting the workshops, and the collective experiences of the committee members who are affiliated with local and international research and academic bodies. It is believed that there is no single solution that will effectively resolve the issue of marine litter overnight. It is also increasingly recognised that integrated cross-sectorial action, focused on both upstream and downstream interventions, are required to tackle this pressing global issue. The work conducted and presented herein addresses these cross-sectorial approaches along with exploring the level of public engagement on the issue, in recognition of the fact that changes in consumer and societal behaviour will be key to successful intervention actions. The issue of marine litter is also interlinked with that of waste management (as a whole) which is a pressing matter for the state (in general) and Gulf countries (in particular), and therefore cannot be tackled without touching on that matter. The practices of waste management and its accumulations, in addition to, crossing environmental sinks between terrestrial to marine; is a matter of great importance that needs to be addressed in the near future.

This white paper evaluates in specific the following elements that revolve around assessing and minimising marine litter accumulation:

- Past and future trends of pressure caused by litter on the marine environment,
- Current, and predicted future status of the marine environment in context of marine litter accumulation,
- Overview of waste management in Kuwait and other Gulf Cooperation Council Countries (GCC),
- Current and future impacts on social and economic aspects caused by litter,
- Future action-plan proposed to combat the issue.

The report also provides an independent state-of-the-art summary of scientific understanding of the issue. The work is solely based on existing publicly available scientific information. Knowledge gaps are identified and acknowledged as well. The report concludes with an independent knowledge base to inform the development of policy and research actions.

Background to the Problem

The term "marine litter" or "marine debris" has been introduced to describe discarded, disposed of, or abandoned man-made objects present in the marine and coastal environment. It consists of items that have been made or used by people and subsequently discarded or accidentally lost [1-2]. It is now recognized that marine litter is a major global problem with its origins predominately originating from land-based (terrestrial) sources [3]. It is also important at this stage to set a few standard terms (and definitions) in place for the benefit of the reader, as terminology both in technical literature and scientific publications might overlap and cause confusion. The accumulation and ecological consequences of fine particles in the marine environment (namely plastics) have brought out the use of the terms "microlitter" [4] and "microplastics, MP" [5]. MP should not be confused with microlitter which has been defined previously by Gregory and Andrady [6] as waste/debris particles that can pass through a 500 µm sieve but are retained by a 67 µm sieve (range between 0.06-0.5 mm in diameter). Anything larger than such particles is denoted as mesolitter that could originate from various organic or inorganic sources [7-8]. Therefore, the terms marine litter encompasses both macro to micro scale debris and particles in the marine environment. A detailed sketch of scales/identification methods that illustrates the distinction of such is given in ***Figure 1*** below.

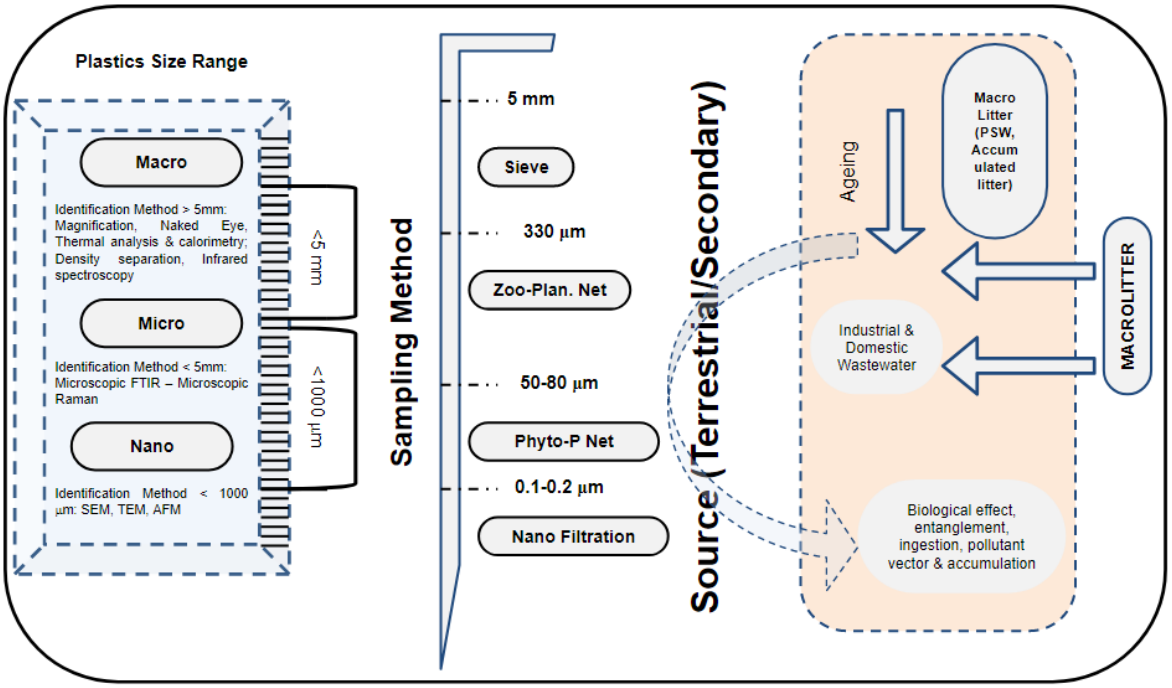


Figure 1. Sampling and Identification Methods of MP Encompassing Classification of Plastic Material and Major Effect on the Marine Environment. Adapted from Al-Salem et al. [8].

Data demonstrates that man-made litter can be found in nearly every marine environment, from coastal zones near major urban areas, to the deepest parts of the ocean and remote areas of the Arctic ice sheet [9-14]. Its composition includes materials such as metals, ceramics, glass, textiles and wood. However, by far the largest and probably most harmful fraction of marine litter is plastic-based, and it has been estimated that annually 13 million tonnes enter the ocean and the surrounding environment every year [15].

Marine litter can have a direct impact on wildlife, causing injury and death of marine birds, mammals, fish and turtles as a result of entanglement and/or ingestion [16, 18]. Research conducted in Australia has shown a 50% probability of mortality in marine turtles that had ingested 14 pieces of plastics [101]. Various species of sea turtles face a direct threat by increase of mortality rate due to ingestion of debris such as *Caretta caretta, Chelonia mydas, Eretmochelys imbricata, Lepidochelys olivacea, and Dermochelys coriacea*. Such reports stem from around the globe including coasts of Japan, Brazil and the Hawaiian and American Samoan longline fisheries [19-21]. In addition, varieties of species have been reported to confuse debris as prey which leads to its ingestion. A prime example of such is sharks,

mesopelagic fishes, mojarras, tuna, groper, mullet and catfish [22]. On the other hand, field samples vary from the Baltic Sea to the Arabian Gulf in the range between 0.03 particles per fish to 21.8, respectively [23]. While 95% of the sea bird species, Northern fulmar (*Fulmarus glacialis*) sampled in the North Sea had plastic (on average 35 pieces weighing 0.31 g) in their stomachs [18]. Studies also show species of zooplankton ingesting plastic debris when found in abundance. This is typical when MPs are aged in the marine environment. The increase in size of debris also causes a higher risk of indigestion by a variety of marine species, in addition to leaching of chemicals and acting as a carrier (vector) of pollutants, and shaving MPs influence the growth of microalgae and zooplankton feeding [24-25].

Recent studies have highlighted the risks posed by plastic bioaccumulating in marine species destined for human consumption, and the potential effects on health [26]. Beyond the direct environmental impacts, plastic pollution has extensive social and economic impacts [1-2]. Globally, the UN Environment Programme (UNEP) suggests that plastic waste causes $13 billion worth of economic damage to the global marine ecosystems every year [27]. Furthermore, regional assessments of the economic impacts of marine litter have been undertaken in the Asia-Pacific region with tourism, fishing and shipping industries estimated to be impacted by $1.3 billion per year, while in Europe the price of cleaning litter from its coasts is estimated to be $720 million per year [1,27].

The disposal of plastic solid waste (PSW) and the threat it poses to the marine environment is emerging as an important environmental challenge in the Middle East (ME) [28-31]. In particular, the waters of the Arabian Gulf (hereafter referred to as the Gulf), which is bordered by Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE), may be particularly susceptible due to a combination of demographic, socioeconomic and environmental factors. The Gulf is bordered by countries undergoing rapid economic and population growth [32]. Several countries have already developed more than 40% of their coastline and recent data identifies the Gulf Cooperation Council (GCC) countries comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE), as having one of the highest global population growth rates [33]. This unprecedented rate of development has been shown to pose significant environmental and socioeconomic challenges

[32,34-36]. Pressure on the coastal and marine ecosystem is especially high in countries such as Bahrain, Kuwait, Qatar and the UAE where most of the population live within close proximity to the coast [32].

The Growing Waste Issue in Countries Surrounding the Arabian Gulf

The gross urban waste generation in the ME exceeds 150 million tonnes per year [37]. In affluent GCC nations, PSW comprises between 11% to 24% in municipal solid waste (MSW) [37-43]. PSW in the region is continuing to grow with the increase in consumer spending which translates to higher consumption of plastics, particularly those which are designed to be single use. Globally, the consumption of bottled water, which reached 100 billion gallons in 2017, is helping to drive the boom in plastic bottle production and use [44]. Countries such as UAE, Kuwait and Saudi Arabia are regularly in the top 10% of global consumers per capita of bottled water and it is estimated that the average UAE residents will consume 450 plastic bottles annually [45]. Additionally, the region has high consumption rates of single use plastic bags, originating from the grocery and retail sector. In 2013 the UAE's Ministry of Climate Change and Environment estimated that residents in the Emirates were using 11 billion plastic bags annually, adding up to a yearly overall waste load of 912.5 kg per capita [45]. This reflects the extent of plastic bags and bottles used in the region and the pressures placed on the developing waste sector, where recycling rates are generally below 10%, which while not uncommon globally, fall below more developed sectors, such as the European Union (EU) where rates are closer to 40% [46].

Table 1 below summarises the status of solid waste (SW) generation whilst depicting the main characteristics of GCC nations. Furthermore, a shared common factor amongst these countries is reliance on landfilling (typically unsanitary manner) for the disposal of waste [48]. It should also be noted that PSW generated from terrestrial sources, and in general SW; contribute immensely to marine litter and is considered to be the main factor that leads to debris accumulation [48]. The main treatment technologies and pathways are also depicted herein for a selection of GCC countries and Iran in ***Table 2***. Based on recent assessments in

Kuwaiti waters, as well as other GCC coasts; most particles detected from fish and sediment are likely from terrestrial waste sources. Therefore, the mismanaged fraction of SW namely PSW is the most irksome element that should be focused upon hereafter in GCC countries.

Table 1. Main characteristics of the Arabian Gulf bordering countries, including estimated plastic waste generation and main waste management technologies utilized. Adapted from Al-Salem et al. [8].

Country	Population (million residents)[1]	GDP (M$)[2]	SW Generation (mtpa)[3]	PSW Generation (mtpa)
Kuwait	4.13	120.12	1.75	0.31[4]
Oman	4.63	70.78	1.73	0.20[8]
U.A.E.	9.40	382.57	5.41	1.29[9]
Iraq	38.27	192.06	13.14	N/A
Bahrain	1.49	35.43	0.95	N/A
Saudi Arabia	32.94	686.73	16.12	1.92[5]
Qatar	2.63	166.92	1.00	0.13[6]

[1]Total population of nationals and expatriates as of 2017 in accordance with World Bank statistics; [2]Based on the year 2017 forecast of the World Bank [47]; [3]Generation of municipal solid waste (MSW) extracted from World Bank report based on million tonnes per annum (mtpa) [47]; [4]Based on [38-39] taken as 18%; [5]Taken as 12% of total MSW based on [40]; [6]Taken as 13% of total MSW based on [41]; [7]Based on PSW composition (11%) declared by the World Bank report [42]; [8]Taken as 12% of total MSW based on [37]; [9]Taken as 24% of total MSW based on City of Dubai Statistics published by Saifaie [93].

Table 2. Selection of GCC nations (and Iran) Showing WM pathways [49].

Country	Composting (%)	Controlled landfilling (%)	Incineration (%)	Open dump/unsanitary (%)	Recycling (%)	Unaccounted for waste treatment (%)	Waste treatment/Waterways (%) or Landfill gas generation (%)
Kuwait				100			None
Qatar			4		3		
Emirates	9			62	20		
Iran	12	10	0.4	72	5	0.3	
Oman		0.01		99.99			

The Extent and Impact of Marine Litter in the Arabian Gulf

The frequency of occurrence, composition, and distribution of litter accumulating in the marine environment of the Arabian Gulf is relatively unknown and needs further investigation [7-8,29]. A limited amount of peer reviewed literature is available, while more general data originates from the various beach clean initiatives that occur across the region and other studies that focus on pollution of the Gulf in general (see ***Table 3***).

One of the earliest reports on studies conducted in the1990s documented the presence of industrial plastic pellets along the shorelines of Oman and the UAE [50]. The study documented widespread pollution of plastic production pellets (also referred to as nurdles), predominantly around the shorelines of the UAE (approx. 1000 – 60,000 pellets per m^2) and to a lesser extent Oman (approx. 50-200 pellets per m^2). The density of pellet pollution varied greatly and even included intact 25 kg sacks containing the pellets that had been washed ashore. At the same time as this study the production volumes of polyethylene, vinyl and polyvinyl chloride were dramatically increasing in manufacturing facilities in the region and the authors linked this to a possible worsening of the situation in the years to come [50].

Few other studies describing the composition and abundance of beach litter in the Arabian Gulf are currently available. On the other hand, studies from Oman are over 15 years old and at the time reported a relatively low density of litter pollution compared to other global studies [51]. The study examined a series of 100m transects on 11 beaches west of Muscat. The beaches were sub-sampled on two consecutive months with plastic and fishing related debris dominating the makeup of the litter recorded [51]. More recently, work published in Iran employed OSPAR guidelines and identified plastic and polystyrene based products, including caps/lids, drinks bottles and crisp/sweet packets dominating (74-81%) the composition of beach litter on a stretch of RSA coast close to Bandar Abbas in the Strait of Hormuz [52]. Further analysis of the data indicated that tourism and recreational activities were responsible for more than 90% of the litter observed on the beach surveyed. Similar compositions of beach litter have been reported for the area in a follow up study investigating MP concentrations in coastal sediments [53]. While these initial studies predominantly focused on sandy shores, data has been published for other types of coastal habitat [54].

A survey of 4 mangrove forest locations on the Gulf coast of Saudi Arabia confirmed that such habitats can act as traps for marine litter. The plastic waste accounted for 95% of the total litter items observed with rope, plastic bags, food, and drink containers dominated the composition recorded. The make-up and density of litter was linked to the proximity of the sampling locations to major shipping routes, which was suggested as the main source of the items observed [67]. Globally, cigarette butts are the most common form of litter in the marine environment and studies have documented their widespread abundance along the shorelines of the Gulf [68-69]. Such debris, while causing aesthetic problems, also poses a toxicological risk via the metals and other contaminants associated with used cigarette butts [69]. A limited amount of data has been reported during voluntary beach cleans and captured via 'citizen science' data hubs, such as those supported by the Clean Swell initiative [70]. While not at the resolution of surveys conducted under internationally recognised guidelines such as UNEP or OSPAR, the data identifies plastic waste as the main source of marine litter pollution in the region.

Table 3. Summary of Main Peer Reviewed Literature on the Gulf with respect to MP abundance, debris and chemical pollutants.

Reference	Country/Study area	Main Results/Findings
Abayomi et al. [55]	Qatar/8 beaches and 4 surface stations coast	Fibres (1-5 mm) were the most dominant type found with a maximum abundance of $1.46x10^6$ particles.km^{-2}
Abbasi et al. [56], Akhbarizadeh et al. [57], Aliabad et al. [58]	(Iran) Different locations along coast and Chabahar Bay	828 MP (fibres) were detected and the range of 5.66 ± 1.69 to 18.50 ± 4.55 item/10 g fish muscle of MPs.
Khordagui and Abu-Hilal [50]	UAE	22771 items collected of which plastic fragment constituted 27.1%
Saeed et al. [59]	Kuwait/Shoreline	37 particles in sediments and 3 particles in gut content of grouper
Al-Salem et al. [28]	Kuwait	1 MP in 3 different type of fish species namely *Acanthopagrus latus, Acanthopagrus latus* and *Lutjanus quinquelineatus*
Naji et al. [53,60-63]	Iran/Bandar Abbas, Strait of Hormuz and Khor-e-Khoran	307 MP were identified and the distribution of particles (<1 mm) in mangrove surface showed that over 70% (10 – 300 µm) particles were predominant and the main source were sewage outlets.
Agah et al. [64]	Oman/Chabahar Bay (Oman Sea)	Naphthalene, Acenaphthylene, Acenaphthene, Fluoren, Phenanthrene, Anthracene and Fluoranthene Benzo(a)anthracene PAH levels of water were higher in post-monsoon season.
Lyons et al. [65]	Kuwait	Studied the following: PAH, PCB, HBCD, brominated flame retardants and metals. Moderate contamination observed mainly close to industrial site on coastline.
El-Sorogy et al. [66]	Saudi Arabia	Study coastal sediments for metal contamination. Enrichment factors indicated anthropogenic are the main cause namely, sewage effluent, landfilling due to coastal infrastructure development, oil spills, petrochemical industries and desalination plants in Al-Jubail industrial city.

The entanglement or entrainment of marine animals in marine litter, particularly that associated with the fishing industry (old traps or nets) has been widely reported in a growing number of studies on a global scale [71]. Within the Sea of Oman, there are reported mortalities of leatherback turtles (*Dermochelys coriacea*) attributed to lost fishing gear [72], while 52% of documented turtle mortalities in Abu Dhabi was linked to illegal or abandoned nets [73]. More detailed research into the impacts of ghost fishing by abandoned or lost fishing gear have been conducted in the waters off the coast of Muscat [73]. Experimental field-based studies used deployed traps (termed gargoors) to simulate lost fishing gear. The study showed that traps, once discarded, still had the potential to capture 1.34 kg/trap per day, which was modelled to predict mortality rates of 67 kg/trap and 78 kg/trap over a 3 and 6-month period respectively. Significantly, from a fisheries management perspective, the traps still targeted commercially important species, which accounted for 83% of the species caught once the traps were abandoned.

Recent work has also highlighted the risk of such abandoned traps pose on marine turtles, with work from the UAE implicating them in the standings of green sea turtles (*Chelonia mydas*), an IUCN Red List endangered species [74]. The same study documented extensive perforation of the gastrointestinal tract in a stranded *C. mydas*, resulting from the ingestion of rusted gargoor (fish trap) fragments. In addition, further studies identified the extensive presence of ingested plastic items in the stomachs of *C. mydas* found stranded along the eastern coast of the UAE [75]. The survey, which examined 14 stranded turtles, observed the consumption of plastic in 86% of specimens (61.9 ± 17.2 items of 1.0 ± 0.3 g mass) which was dominated by white and transparent sheet like plastic. In 2001, studies conducted at Ra's Al Hadd in Oman found litter only represented 7% of the food items recovered (dry weight) in stranded *C. mydas* [76], whereas studies conducted in previous decades had failed to observe any litter in the stomach contents of stranded *C. mydas* sampled from the region [77]. Such findings mirror global trends, which highlight the increasing likelihood that marine turtle species ingest marine litter [78].

Along with the direct introduction of MPs into the Gulf (via accidental spills or the wastewater system), the breakdown of larger plastic items will contribute to the deposition and

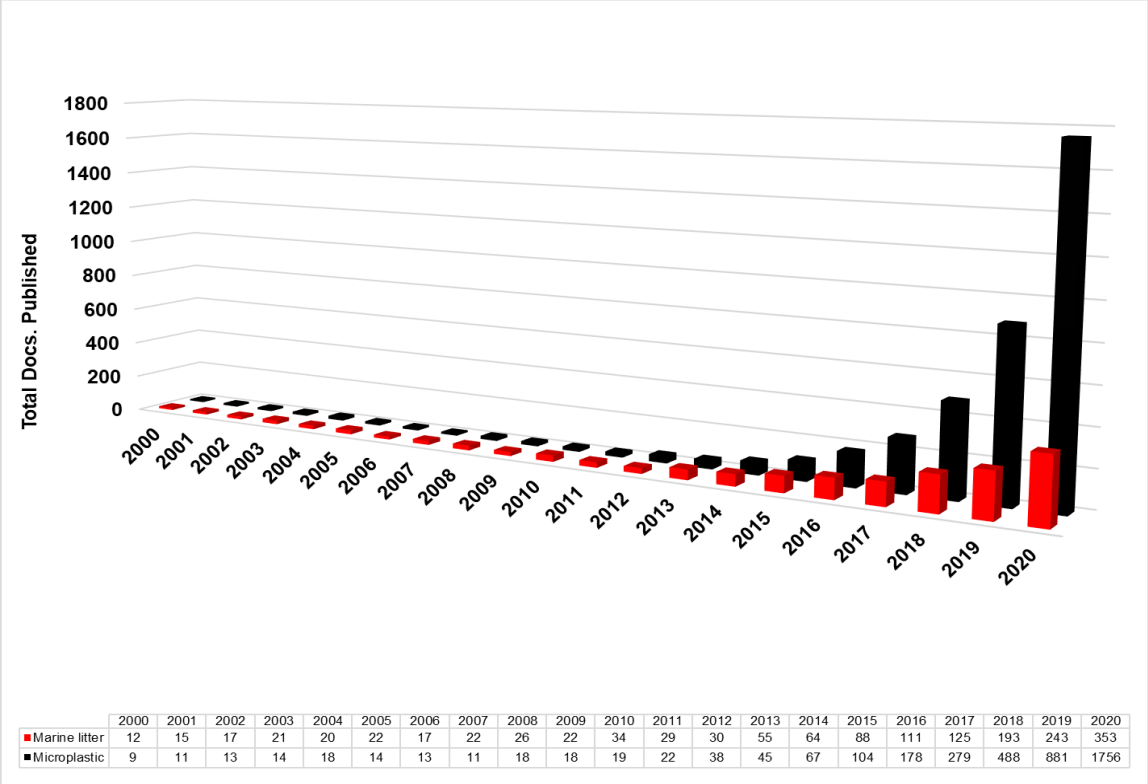
accumulation of MPs in the marine environment, especially as rates of degradation are accelerated in the harsh environmental conditions of the region [34]. Baseline studies of MPs for the RSA are now starting to emerge with data available for MPs concentrations in the offshore marine waters of Qatar's Exclusive Economic Zone (EEZ) [79]. Concentrations detected (0-3 MPs m^3) were similar to those reported for Northeast Atlantic and European coastal waters [14,80]. Castillo et al. [79] identified thirty, mainly granular or fibrous MP polymer types in surface seawater samples using Fourier Transform Infrared (FTIR) spectrometry, with polypropylene dominating the composition. Furthermore, Abayomi et al. [55] employed different sampling and reporting methods and discovered concentrations of MPs in seawater samples to be in the range previously reported for marine coastal waters [81]. Fibres were the predominant MPs at all sampling stations, representing 94% of the total plastics identified. In the study, intertidal sediments were collected from locations around Qatar and examined for MP contamination [55]. Results showed no significant differences between the populated and remote areas sampled, with the authors suggesting that MPs are evenly distributed in intertidal sandy sediments around Qatar. This was attributed to a combination of effective beach litter clearance in residential areas and sources of MPs, mainly originating from sea-based sources with the local fragmentation of beach litter making a smaller contribution. Similar to work reported elsewhere, fibres (44%) were the most abundant form of MPs identified followed by films (40%) and fragments (14%) [55]. Furthermore, studies of intertidal sediments along the Iranian coast of the Strait of Hormuz also identified fibres (83%) as the most abundant MP type [60]. The number of MP/kg measured was linked to the level of anthropogenic activity in the area where polyethylene (PE), nylon, and polyethylene terephthalate (PET) were the predominant polymers detected. Sources of MPs were identified as beach debris and fishing gear, along with the fibres associated with both municipal and industrial wastewater. The authors conducted a follow-on study in the same area and again identified fibres linked to wastewater discharges associated with littoral sediments [61]. Similar studies conducted on Khark Island, located in the southwest of Iran, observed that fragments (61.7%) dominate the make-up of MP in intertidal sediments [57]. Concentrations varied between sites, but as with previous studies,

a positive correlation between human population density and industrial activity, with the abundance of MPs, was observed.

It is now recognised that both land-based and ocean-based sources contribute to the concentration of MPs in marine samples. A growing body of evidence has documented the ingestion of MPs and larger litter items in marine organisms, including commercially important species [26]. It is also known that MPs can act as vectors for organic and inorganic pollutants in aquatic environments, posing a potential toxicological threat to wildlife and humans as they enter marine food webs [8,82]. Studies in the Gulf have also highlighted this risk, with data identifying MPs and their potential for marine food chain accumulation in marine mollusc species sampled from within the Strait of Hormuz [62]. Further studies have also identified MPs and metals in the edible portions of fish including the orange spotted grouper (*Epinephelus coioides*) and pickhandle barracuda (*Sphyraena jello*) caught within the Gulf [57]. The studies estimated the intake of MPs is between 169 and 555 items per portion (estimated at 300 g-week) consumed. The work described highlights the issues encountered when studying MPs, where differences in the definition (size limits) and methodologies (e.g., sampling and reporting units) adopted by different research groups make direct comparison between studies difficult. However, the values detected were similar to those previously reported in the Mediterranean [83] and Northern Europe [84].

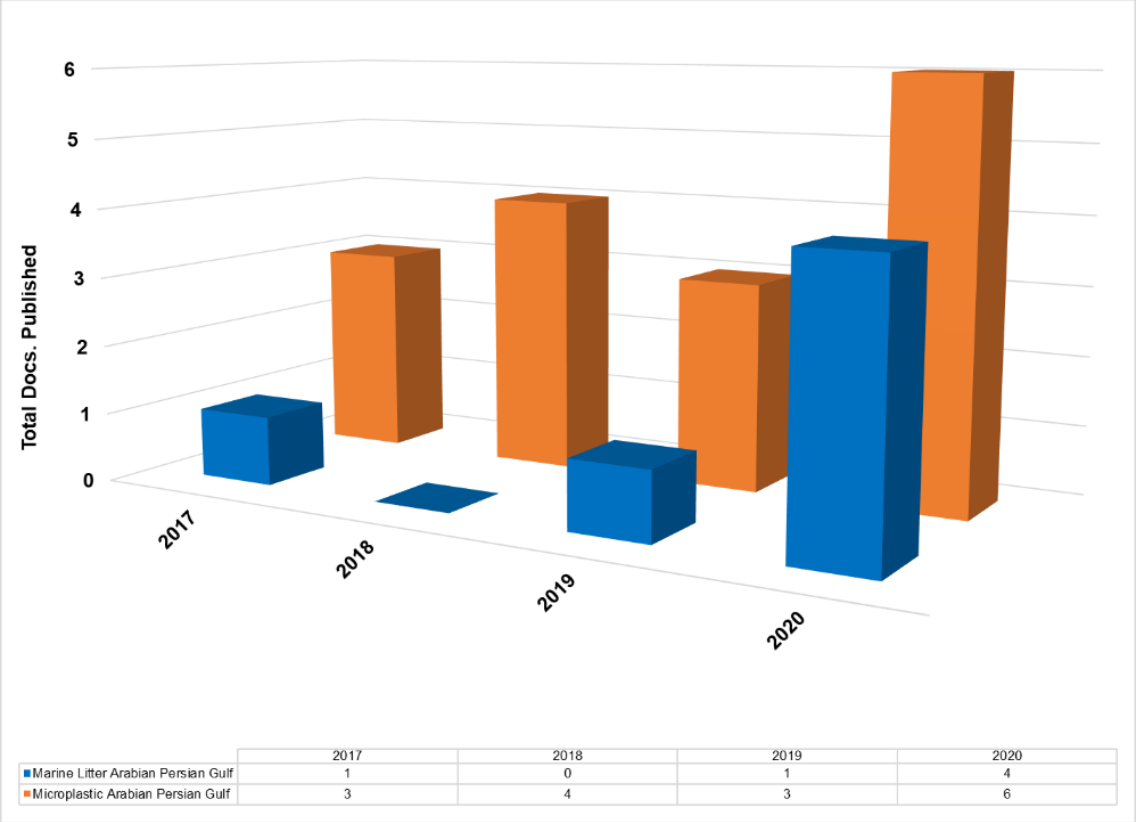
Moreover, Al-Salem et al. [28] identified MPs in commercially important fish gut contents in Kuwait with sizes around 1 mm of PE origin. Collectively, GCC countries produce a collective amount of over 20 million tonnes per annum of polypropylene (PP), high density polyethylene (HDPE), linear low-density polyethylene (LLDPE) and low-density polyethylene (LDPE) [85]. These polymeric resins are the main constituting elements of day-to-day commodity commercial grade plastics. These are also the main contributors to accumulated SW due to poor WM strategies in the region. This should be taken into context, as increasing investments have been commissioned namely in Kuwait to boost petrochemical complex market demands exceeding US$ 20 billion [8]. This also provides a major research gap in the field whereby an assessment of the threats and pollutants carried by marine debris and namely MP, should be assessed for the Gulf region under its environmental conditions. Additionally, there has been

an awareness with regards to these issues on a global scale and in the region of the Gulf, which can be seen in the publication of technical and scientific literature. ***Figure 2*** shows the total published literature related to both marine litter and MP. In the year 2000, only 12 articles encompassing the word marine litter were published, MP articles were 9 for the same year. The reader can see the increasing trend globally on both subject matters exceeding 1700 articles published for the latter term (MP) in the year 2020. By comparison to the Gulf related literature and prior to 2017, there were no published work on both terms (***Figure 3***).



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Marine litter	12	15	17	21	20	22	17	22	26	22	34	29	30	55	64	88	111	125	193	243	353
Microplastic	9	11	13	14	18	14	13	11	18	18	19	22	38	45	67	104	178	279	488	881	1756

Figure 2. Total Published Literature as a Function of Publication Year Using Keywords (Marine Litter, and MP) on SCOPUS Database.



	2017	2018	2019	2020
Marine Litter Arabian Persian Gulf	1	0	1	4
Microplastic Arabian Persian Gulf	3	4	3	6

Figure 3. Total Published Literature (Related to the Gulf) as a Function of Publication Year Using Keywords (Marine Litter, and MP) on SCOPUS Database.

Stemming the Tide of Plastic

The primary challenge in mitigating the impact of marine litter is to reduce both land and sea-based sources, as well as to improve the waste management infrastructure/practices to avoid it from entering the marine environment as an initial step. This issue has been at the forefront of several international initiatives. In June 2012 at the Rio +20 the Global Partnership on Marine Litter (GPML) was unveiled [86], this was followed by the Leader's Declaration of the 2015 G7 Summit and the recently published G20 Action Plan on Marine Litter [87], both of which have acknowledged the global risks posed by marine litter. It is widely accepted that marine litter generation and prevention are clearly linked to a variety of human activities and policy areas operating at both national and international levels [88]. Although the impacts of marine litter are felt in the marine environment, as 80% of litter can originate from land-based sources [3] the primary actions to address the issue need to target terrestrial policies

and practices. Therefore, to address both the sources and impacts of marine litter as a necessary legislation, agreements and actions are required across multiple sectors. These need to include litter reduction initiatives focused on waste and wastewater management, transboundary issues, product design, shipping, fisheries policies, and consumer driven behavioural patterns [1,14].

Globally, waste management legislation is seen in the broader context of enhanced resource efficiency, now a key cross-cutting policy goal [15]. As awareness of the scale of the marine litter problem has grown, international policy was developed to tackle the issue. In 2018, the European Union introduced a European Strategy for Plastics in a Circular Economy, which outlined a vision and set of management measures to tackle the most common forms of plastic waste littering the environment [89]. Core to the development of this strategy is the move to a circular plastics economy, where the design and production of plastic-based products takes into account the requirements for reuse, repair, recycling and the development and promotion of more sustainable materials.

Along with regional strategies, many countries have implemented their own single use plastic reduction policies [90-92]. At the forefront of this has been the development of legislation to ban or tax single use plastic bags. Globally, such schemes have now been introduced in over 60 countries, including the complete ban of single use plastic bags in several African and Asian countries [92]. In Europe, the first legislation to deter use of plastic bags was announced by Ireland 2002 and closely followed by Denmark in 2003. Other countries in Europe have now adopted a point of sales tax for single use carrier bags, with England and Wales introducing one in 2015. There is clear evidence that these polices have led to reductions in plastic bag use and littering. For instance, the introduction of the tax on plastic bags in Ireland resulted in a 90% reduction in use [90]. While following the introduction of a single-use plastic bag tax in England and Wales, the 7 largest retailers issued 83% fewer bags (equating to over 6 billion bags), compared to the year prior to the policy being implemented [93]. Beyond a simple reduction in plastic bag use, studies have found clear evidence of demonstrable environmental benefits with reduced littering in Ireland [90] and a significant reduction (approx. 35%) in the number of plastic bags found littering the UK's marine environment

[14]. Similar initiatives, implementing bans or taxes internationally have seen success rates in single use plastic bags reduction range from 33% to 96% [92]. Implementation of the PSW management hierarchy is also advised in GCC nations due to the socio-economic nature of these states [94].

Within the Gulf region, the Environment Agency - Abu Dhabi (EAD) is leading the way in developing a response to plastic-based pollution. EAD has drafted a comprehensive single use plastic policy (2019-2023) which manages the 88 of the most common single use plastics found globally in marine litter. The approach follows the model of the European Commission with the proposed policy positions for specific single use plastics adopted, based on those plastic items with clear behavioural and sustainable alternatives (the likes of plastic bags, straws and cutlery), items with some alternatives (e.g., plastic bottles and beverage cups), and items with currently no or difficult alternatives (cigarette butts, sweet and crisp wrappers). In addition, EAD is planning a baseline study of both marine litter and litter in terrestrial areas to gain a better understanding of plastic items that are entering the environment and causing harm. The problem items identified during the baseline survey will be added to the single use plastic management list if required. More broadly, the medium-term, policy effort will address the fundamental waste management gap identified in EAD's State of the Environment Report (2017): a lack of incentives and deterrents in the absence of adequate infrastructure to encourage the proper management and treatment of waste. The focus will be on transitioning to a closed loop circular system for plastic production, recycle and reuse, based on the Extended Producer Responsibility principle.

In the State of Kuwait and as of recent efforts by Kuwait Municipality (in collaboration with various governmental entities such KISR, KEPA and PAI), new legislations are set in motion to govern the use and standardise *biodegradable* plastic bags. Furthermore, the Kuwait Institute for Scientific Research (KISR) has executed work to simulate the degradation of plastic films simulating plastic carrier bags in the marine environment to understand the potential degradation of such items in the sea using local resins from Kuwait. Additionally, KISR has put forward one proposal of studying MPs impact in NW Arabian Gulf in

collaboration with various international bodies as well. The work is expected to be funded and supported soon.

Furthermore, KEPA has recently launched a marine litter assessment program which covered twelve (12) locations in Kuwait under the name of 'Yalik Natheef – *Your Shore is Clean*'. The exercise has extended between January and February of 2021 and did cover plastic debris collection/segregation as well (see Appendix B for full details of the field results). Overall, the field assessment has yielded the following results (by type) of the collected debris in various locations in Kuwait: Plastic bottles (50%), plastic crates and bottle caps (20%), foam/polystyrene (10%) and miscellaneous including high density PE (20%). The input of marine litter from sea-based sources is being tackled at an international level with legislation and technical support aimed at reducing the littering from lost or abandoned fishing gear [95-96]. The abandonment of fishing gear is specifically prohibited by the International Maritime Organisation in its Convention for the Prevention of Pollution from Ships (1973), but local oversight and enforcement with the RSA often lack political support and are difficult to implement.

Developing Regional and National Action Plans to Tackle the Issue of Marine Litter

Developing national and regional actions plans to tackle the threat of plastic pollution should be seen as a priority for the State of Kuwait and other countries surrounding the Gulf [29]. A growing number of national and regional frameworks are being implemented around the world, many of which could be used to guide the development of similar plans for the Gulf states [97-100]. It is acknowledged that different approaches can be adopted, which tackle regional priorities, and often these plans set the scene for the development of harmonised national action plans and sharing best practices.

The process for developing national action plans is outlined in ***Figure 4.*** This includes initial scoping and stakeholder mapping exercises and would include (but not limited to) marine litter, waste management, plastics, recycling and circular economy sectors (Stage 1). This

would be followed by a R&D phase to address gaps in data and capacity identified (Stage 2). Work in Stage 2 would include scientific surveys (to identify sources and sinks of litter pollution), stakeholder training, workshops and infrastructure gaps. Stage 3 is critical to the success of any national action plan, as it allows for the stakeholders to be consulted and increases the chances that the final plan will be adopted and implemented by the concerned authorities. The final stage is review and adoption (Stage 4).

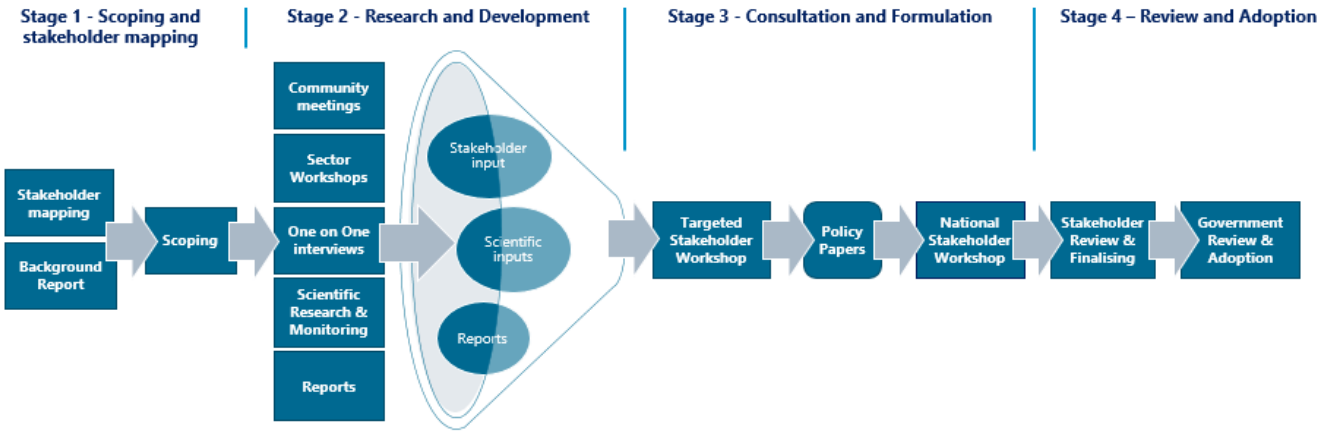


Figure 4: Stages of the process towards the creation of an action plan to tackle marine litter.

Adapted from Kohler et al. (submitted)

The development of national action plans, such as those developed by EAD in the UAE is clearly an essential step. This allows accounting various essential parameters including the differences in national capacity, stakeholder engagement, government policy, local waste management practices and public awareness. There are examples of regional plans which may be adapted to meet the needs of the RSA. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) has developed one such plan [97]. The approach adopted in developing the PERSGA marine litter regional action plans was to establish strategies, objectives and priority actions based on an assessment of coastal and marine litter in the PERSGA region. This was based on information gathered via questionnaires distributed to key government entities and stakeholders across PERSGA

members' states, which were then used to develop a series of high-level strategic goals and associated objectives and actions. Similar approaches adopted by HELCOM [99] and OSPAR [98], the Regional Seas Conventions in the Baltic and North East Atlantic respectively, have established marine litter regional action plans based on defining strategic goals, objectives and specific management actions to address:

1. Land-based sources of marine litter (including macro and MP)
2. Sea-based sources of marine litter (from both recreational and industrial sources)
3. Education and outreach on marine litter
4. Removal strategies.

Considering these examples, it is believed that a framework is provided for the implementation of a regional action plan suitable for the Gulf and elements of these should be integrated into National Policies to tackle plastic pollution (***Table 4***). The implementation of a marine litter action plan should be supported by a coordinated monitoring programme to identify primary sources of marine litter to inform targeted interventions, and to assess progress in relation to the objectives of the action plan. While such baseline monitoring is being established in certain countries (e.g., as part of EADs national single use plastic policy), they are yet to be adopted in a consistent manner in Kuwait. Developing monitoring programmes requires a consensus to be developed on methods to employ (e.g., litter classification scheme to adopt) and bodies, such as the Regional Organisation for Protection of the Marine Environment (ROPME), best placed to drive forward such initiatives.

Research and development (R&D) efforts are believed to be essential at this stage, a summary of which is provided in ***Table 4*** below. First and foremost, R&D efforts should focus on identifying the major sources of marine litter in Kuwait using observational methods and mathematical modelling strategies for future predictions, as well as in light of SW generation rates. The debris that ends in marine bodies (in this case the Arabian Gulf) could originate from various sources that are of terrestrial nature and airborne (e.g., end of life tyres, landfill sites, marine activities on shore, etc). Furthermore, a national flagship project with stakeholders should be undertaken pertaining this area of research with a clear baseline classification for future types of macro and micro debris.

The growing issue of marine litter in Kuwait and across the Gulf demands a concerted effort from policymakers and urban planners to devise an effective waste minimisation, collection and recycling strategy to tackle the issue of plastic wastes. The continued development and implementation of marine litter reduction plans, at both a regional and national level, will enable the integrated and cross sectorial approaches that are required to tackle the environmental, socioeconomic and human health threats posed. This will help to address the infrastructural roadblocks, lack of awareness and low level of community participation, which are major factors behind the increasing generation of plastic wastes and the resulting adverse impact it has on the region's marine environment. Furthermore, there should be a clear programme to execute a project that will assess the impact of marine debris on species that are indigenous to Kuwait's marine habitat. Along with the points identified in ***Table 4***, a clear monitoring programme should be established with a guideline for marine litter. This will help in preserving and rebuilding the health of the Gulf which is exposed to various effluents and sources of pollutants including marine litter. It is proven that 45 fish and invertebrate species, including deep sea species, and 56 bird species, have been found to ingest MP [102]. A survey that assesses the potential species exposed to MP should also be included to have a clear indication as to what type of species are expected to face fatal end by exposure to debris.

Additionally, pollutants and additives present in plastics are to be assessed in Kuwait against what is expected to be *sorped* by marine debris. Generally, there has been quite a controversy pertaining health impact of humans with regards to marine debris exposure. It is a relatively new research area that is closely tied with economic losses of areas that are infested with marine debris as described previously by Gold et al. [103], where costs of clean-up of beaches, costs associated with damage to or loss of fishing gear or obstruction of motors, eventual cost of hospitalisation from marine debris related health impacts, are tied into exposure to human health. Further losses in economy are described as loss of revenue from fish or loss of income from tourism. It is quite essential to understand the fact that marine debris acts as a nucleus that facilitates accumulation of toxins, which becomes several orders of magnitude higher on the surfaces of plastics [104].

Additives such as bisphenol A (BPA), flame retardants and PCBs are associated with major risks to human health and hormonal imbalance which is also easily transferred through the food chain. The behaviour of marine debris of all sizes and their dynamics, spatial distribution in addition to the relationship between composition, surface texture, and degradation of plastics/marine debris and socio-economic; are all knowledge gaps that are worth further studies [105]. Chen [106] estimated the associated cost of marine debris in the Pacific Rim is approximately €949 million on an annual basis. Moreover, Alqattan et al. [107] depicts the most hindering factors of commencing a 'blue economy' in Kuwait and has highlighted waste effluents into marine environment as one of those. Such studies are essential for Kuwait and the GCC area as well, which also is presented as a knowledge gap as per the following: Kuwait to establish data collection and monitoring frameworks, including standard protocols for sampling laboratory testing and data collection to establish the flows and flux of plastics into the marine environment. This action plan can be summarised as per the following:

- Report regularly on the distribution of plastics and microplastics in the environment to better facilitate the monitoring and evaluation of plastic pollution reduction mitigation measures.
- Establish a framework for identifying alternative materials to existing plastic products where substitution is a viable option, based on a full life-cycle approach for key plastic products found in litter and develop road maps (including cost) to switch to alternatives.
- Identify economic losses associated with real-time data assessment and monitoring of marine debris data.
- Develop national multi-stakeholder communication plans to raise awareness of the issue of plastic in the marine environment and help change human behaviour towards those that minimise the mismanagement of plastic waste.
- Develop health and toxicological indicators that can establish the risks micro and nano plastics pose to humans and wildlife.

In summary, there is no single solution that will effectively resolve the issue of plastic pollution and it is increasingly recognised that holistic cross-sectorial action, involving both upstream

and downstream interventions, will be required. Such approach will need to extract knowledge from multiple stakeholders (local communities, municipalities, government ministries, regional sea conventions, NGOs, universities, and the private sector), informed by scientific studies and waste composition analysis.

A workshop was held to on the 22nd of March 2022 to discuss the marine litter white paper with the relevant authorities, resulting in the following recommendations: -

- The need for concerted efforts from all parties to implement the recommendations mentioned in the white paper, namely with concern to constant monitoring and applying international laws of marine litter/waste management.
- Studying the sources of this waste and identifying the various sectors responsible for it to provide appropriate solutions and treat it accordingly.
- Establish an entity to manage the tasks related to marine litter and create a specialized team to provide technical support and to collect and update the data on a regular basis.
- Consider the issue of scientific research and development, fill research gaps in the field of marine waste and include studies of marine areas of high sensitivity, such as coral reefs and marine plants, ensuring its application.
- In light of current scattered efforts with state authorities, it is recommended to increase community awareness through campaigns for citizens and residents as well as involving them in monitoring and data collection.
- Commit to the rules and regulations without laxing in the application of laws to deter violators and limit violations.
- Benefit from the efforts and activities undertaken in sustainable cities, such as reusing and recycling programs, and disseminating successful experiences to all areas of the country.

Table 4. Proposed framework for establishing and implementing a Marine Litter and Single Use Plastic Action Plan*.

Priority	Theme	Overview	Objectives	Actions
1	**Governance**	Establish a national working group of marine technical, waste management and environment specialists to work on developing and implementing the Action Plan.	Establish an entity for the mechanism of developing a regional response to the marine litter and single use plastic issue.	Develop a national taskforce on marine litter.
			Establish a taskforce term of reference (ToR) for managing single use plastics and marine litter in Kuwait.	Taskforce develops ToR and approve / modify Action Plan.
2	**Action Plan**	Develop a clear action plan to respond to the marine litter and single use plastic issue in Kuwait.	Develop a National Action Plan.	Develop an Action Plan with objectives, actions, time frames and implementation mechanisms with relevant stakeholders. Key stages include: Scoping and Stakeholder mapping; Data gathering (community/ stakeholder meetings, R&D requirements); Consultation and Formulation (policy options, national committee workshops); and Review and Adoption.
3	**Research and Monitoring**	Focus on understanding the status of coastal and marine litter in Kuwait and the Gulf Region in terms of impacts and management and develop a regional baseline of marine litter.	Assess priority sources and types of marine litter.	Develop a standardised methodology for sampling, laboratory testing and data collection to measure the flux and flows of litter and plastics into Kuwait's marine environment. Approaches should include the use and development of earth observation and remote sensing (e.g., satellite and drones) as well as the development of AI to identify litter items.
			Understand the impacts of litter on the coastal and marine environment, considering environmental factors of the Gulf.	Implement studies on the impact of accumulated litter, including fishing gear, on coral reef communities and

Priority	Theme	Overview	Objectives	Actions
				other sensitive habitats (e.g., sea grass beds and mangrove forests).
			Assess risk posed by microplastic contamination of the marine environment.	Develop standardised study protocols to investigate the sources, fate and effects of microplastic contamination in marine waters, sediment and biota.
			Investigate effects of coastal and marine litter on human health.	Search for records of human health affected by litter that has accumulated on beaches or in the sea within the region.
			Investigate the economic impact of marine litter.	Conduct economic evaluations of the impact of marine litter on different sectors, such as tourism, fishing, shipping and desalination industries.
			Invest and develop in technology to promote a circular plastics-based economy.	Develop partnerships with the industry value chain in activities aimed at increasing the sustainability of plastics through their life cycle.
4	**Awareness and Education**	Reduce and/or prevent the accumulation of litter on beaches and in the sea through the involvement of a wide range of stakeholders.	Raise public awareness on the impact of marine litter on coastal and marine environments and provide continued education programs for a sustainable future.	Organize awareness workshops and seminars on the impact of marine litter for separate target stakeholders (e.g., schools, fishing communities, private sector, and decision makers).
			Clean-up litter from the coastal and marine environment and establish a plastics monitoring methodology for citizens and groups to follow.	Develop strategies for clean-up campaigns, including methodologies to establish ongoing citizen science led beach / desert monitoring.
			Educate stakeholder groups on marine litter issues via the interdisciplinary supervision and management of the Higher Education	Provide further education and training to ship owners, operators, crews, port users, fishermen and recreational boat users, with regard to international parameters and

Priority	Theme	Overview	Objectives	Actions
			sector with the support of local relevant authorities	regulations in addition to their local sustainable practices and responsibilities in the fostering of a sustainable future and the prevention of marine pollution.
5	**Legal Framework**	Reduce and then eliminate the dumping of litter in the coastal and marine environment and strengthen government capacity to manage marine litter.	Support the regulation of marine litter pollution and its effects on the sea.	Continue to encourage member countries to ratify the MARPOL convention and promote enforcement of Annex V of the MARPOL convention by the member countries that have ratified the convention.
			Share information and exchange experience on marine litter.	Exchange relevant information and experience with other regional and international organizations, including UNEP Global Partnership on Marine Litter and the International Clean-up Campaign.
			Develop capacity building on marine litter management	Support the organization of training courses on marine litter regulation and management in the member countries.
			Build Public-Private-Partnerships (PPP).	Involve non-profit organizations in the activities of the awareness and litter clearance programmes in each member country.
			Develop National Action Plans on marine litter.	Develop a set of regional guidelines for the development of National Action Plans on Marine Litter (NAP-ML).

* Adapted from the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) Marine Litter Action Plan, and the Environment Agency – Abu Dhabi's Single Use Plastic Policy and Implementation Plan (2019-2023)

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Appendix A

Marine Litter Workshop Agenda organised by KFAS between 9-11 November 2020

Marine Litter Symposium
(9th, 10th and 11th of November 2020)
Presentation Abstracts

Day 1 Monday 9/11/2020

Marine litter science: global, regional & national issues

Speaker	Abstract
Dr Brett Lyons	**PRESENTATION TITLE:** **Rising Tide of Marine Litter in the ROPME Sea Area** The impact of marine litter, particularly plastic waste, is widely acknowledged as a growing global concern. Marine litter is an understudied issue in the Regional Organisation for Protection of the Marine Environment (ROPME) Sea Area where rapid economic growth has already placed considerable stress on infrastructure and coastal ecosystems. Here we outline the key drivers for waste generation in the region and review the available literature to summarise the current state of knowledge on the environmental fate, behaviour and impact of marine litter within the ROPME Sea Area. While data is limited, those studies conducted demonstrate marine litter is posing a clear and growing threat to the environmental and socioeconomic prosperity of the ROPME Sea Area. The development of regional and national marine litter reduction plans are clearly a priority to focus and coordinate activity across multiple stakeholders.
Prof. Alistair Boxall	**PRESENTATION TITLE:** **What is the evidence that plastics negatively impact the natural environment?** There is increasing scientific and public concern over the presence of microplastics in the natural environment and several claims have been made about the occurrence, fate and direct and indirect toxic effects of microplastics in the natural environment. The evidence for or against some of these claims is unclear. This study therefore involved a systematic review of the literature to assess the weight of evidence for microplastics causing environmental harm. The study identified 320 relevant articles that were published up until the end of 2017. Analysis of these demonstrated that microplastics do occur in surface water and sediments across the globe. Fragments and fibers predominate, with beads making up only a small proportion of the detected microplastic types. Comparison of the occurrence data with data from ecotoxicity studies shows that concentrations detected are orders of magnitude lower than those reported to affect endpoints such as biochemistry, feeding, reproduction, growth, tissue inflammation and mortality in organisms. The evidence for microplastics acting as a vector for hydrophobic organic compounds to accumulate in organisms is also weak. The available data therefore suggest that these materials are not causing harm to the environment. There is, however, a mismatch between the particle types, size ranges, and concentrations of microplastics used in laboratory tests and those measured in the environment. Select environmental compartments, such as soils, which are likely to be sinks for microplastics have also received limited attention. There is an urgent need for studies that address this mismatch by performing high quality and more holistic monitoring studies alongside more environmentally realistic effects studies. Only then will we be able to fully characterize risks of microplastics to the environment to support the introduction of regulatory controls that can make a real positive difference to environmental quality.

Dr Sultan Alsalem	**PRESENTATION TITLE:** **You Eat What You Waste: Evidence of Microplastic (MP) in Major Consumed Fish Products of Kuwait** The development of an integrated waste management (IWM) masterplan for the State of Kuwait, cannot be complete without a thorough understanding of the environmental sinks and the endpoint of the accumulated solid waste (SW) the country is associated with. Over 200 ktpa of plastic waste generated from various municipal sources on an annual basis, are mismanaged in Kuwait and unsanitary disposal rather than engineered landfilling, takes place by the appropriate authorities. One of the major end points of the state is noted to the Arabian Gulf where either rigid or film macro plastics are being disposed of and littered on its shorelines. One of the main characteristics of the Gulf is it's the shoreline which occupies a total of 195 km with waters on its northern parts being of somewhat of an estuarine nature with a progressive increase in salinity towards the south. The waters surrounding Kuwait are characterized by mean winter temperatures of 140C, mean summer values of 300C and an average salinity that exceed 40%. Kuwait's marine and coastal environment provides multiple social and economic goods and services. Kuwait's marine environment supports productive finfish and shell-fish fisheries for human consumption and the culturally important pearl oyster. Kuwaiti waters also host twenty-three species of fish that are of immense commercial importance for the country. The evidence of microplastics (MP) originating from primary/secondary uptake, is investigated within Kuwaiti waters and major fish products. Firstly, a case study that details such evidence is depicted after investigating a wastewater source/outlet in Kuwait, and thereafter, the results of MP evidence found in major fish gut species are also detailed. It is overseen that with the current situation and PSW management practices in Kuwait, such numbers can only escalate which might cause a serious environmental concern in the near future.
Dr Yousef Alosairi	**PRESENTATION TITLE:** **Fate and Transport of MPs in Kuwait** Marine plastic litter has been a key concern over the past 10 years particularly for the coastal communities in Kuwait. This is since the enclosed coastal regions within the Kuwait Bay has been receiving continuous loads, in which marine plastics could be found in large quantities after every strong wave events. Marine plastics, that vary in size, have resulted in several ecological threats, and perhaps, impact on human health. Therefore, understanding the transport, distribution, and fate is one of the key aspects to evaluate and assess the impact of plastics. These processes are largely controlled by the dynamics of the region. In the current study, we utilise a hydrodynamic model coupled with a particle tracking model to replicate the behaviour of the microplastic. Although, the behaviour of microplastics could not be fully reproduced by the model, the general patterns and transport time scales were representative. The results indicated that the enclosed region of Jahra and Sulaibikhat Bays are favourable for plastics to accumulate and retain for longer periods compared to other dynamic regions which are associated with turbulence. Therefore, Jahra and Sulaibikhat Bays ecology could be categorised as the most affected by microplastics within the Bay. Further studies must be focused on the behaviour of microplastics to obtain suitable empirical representation which would advance models capabilities.

Marine Litter Symposium
(9th, 10th and 11th of November 2020)
Presentation Abstracts

Day 2 Tuesday 10/11/2020

Marine litter science: Governance and waste management strategies

Speaker	Abstract
Dr. Eleni Iacovidou	**PRESENTATION TITLE:** **Plastic Waste (Mis)management and the transition to a Circular Economy** Plastics, due to the many properties they possess (e.g., inexpensive, lightweight, durable, strong, versatile), are now ubiquitously present in our global system, supporting our modern lifestyles. Though, they provide several benefits to our global economy, regrettably they are also associated with numerous shortcomings. In many places around the world, the inappropriate and/or uncontrolled disposal practices, poor waste management and/ or insufficient recycling technologies have allowed plastic waste to dissipate into the environment representing a major threat to environmental quality, and a global system failure. The latter is of particular concern especially in places where the management of plastic waste occurs in a controlled and organised manner, the infrastructure and recycling technologies are available, and a well-functioning regulatory system is operating. Yet, plastic marine litter knows no boundaries. Recently it has been identified that plastic marine litter is a major threat to planetary health on a global scale, causing environmental, economic and social impacts. This has intensified efforts to promote circularity in the plastic waste value chain and maximizing the value yield from plastic waste recovery activities. The quest of closing the plastic waste loop, and of reducing the amount of plastic waste escaping to the environment, necessitates an understanding of the sources, pathways of plastics to the marine environment. Most importantly though, achieving the transition to a sustainable future where plastic waste are properly managed demands an integrated understanding of the underlying systemic causes, failures and opportunities for change.
Winston Cowie	**PRESENTATION TITLE:** **Abu Dhabi's Single Use Plastic Policy – a journey towards reducing plastic entering the environment where it causes harm** Single use plastic entering the environment where it causes harm is one of the biggest threats to the ocean globally. Regionally in the Arabian Gulf and locally in Abu Dhabi and the United Arab Emirates it is an issue with documented adverse impacts on marine biodiversity. As a response the Environment Agency – Abu Dhabi (EAD) embarked on a comprehensive two year process to establish the Abu Dhabi Emirate Single Use Plastic Policy, which was launched in 2020. This presentation tells the story of the policy's development and the key components of the Abu Dhabi Emirate Single Use Plastic Policy.

Samia Alduaij	**PRESENTATION TITLE:** **World Bank support to Kuwait Municipality on Municipal Solid Waste Management and Action Plan** Kuwait Municipality (KM) and the World Bank are working on developing a municipal solid waste management action plan to meet the requirements of the Environment Protection Law No.42 and the National Development Plan, Vision 2035. The action plan consists of diagnosing the situation on the ground, identifying options for future scenarios to inform the action plan, and reach an agreement on a roadmap to be adopted. This roadmap is to be accompanied with several proposed actions to be implemented by the Kuwait Municipality. The planning process will ensure the continuing development and improvement of the services moving forward. The presentation will highlight some of the key challenges and findings related to Municipal solid waste management in Kuwait, as well as some of the proposed objectives for the action planning to improve the overall sector in Kuwait.
Sebastian Frisch	**PRESENTATION TITLE:** **eMisk Waste** Since January 2017, Kuwait has been developing an effective waste management system which minimizes the adverse effects of waste on human health and the environment. This system enables the effective application of the five-step waste hierarchy to ensure efficient, safe and environmentally sound utilization of waste streams as resources.
Dr. Sultan Alsalem	**PRESENTATION TITLE:** **The Development of Plastic Solid Waste Management Strategy in Light of Major R&D Work in Kuwait** The State of Kuwait is noted to be one of the most toxic living environments and highest solid waste (SW) generating countries in the world. There also exist conflicting estimates with regards to the actual data that represent the per capita generation of municipal and other components of waste within the state. Moreover, the country has been trying to initiate various projects and initiatives, concerning the reduction and management of SW components generated from various streams. However, the official standpoint of governmental statistics paints a rather bleak picture concerning SW management and in particular plastic solid waste (PSW). Coupled with a kerbside collection rate of 100%, Kuwait generates some 1.5 kg per capita per day with reports showing that this figure is actually less than one third of the real estimates. Furthermore, PSW comprises over 18% (by weight) of the total generated MSW in Kuwait which is equivalent to more than 200 ktpa from various sources within the state. There also exists a great deal of seasonal variation between summer and winter months, that averages to more than 3% on an annual basis. In this communication, the current practices undertaken by the state with regards to PSW are detailed and shown to underline what are the main elements that are either mismanaged or could be improved with time. Furthermore, the recent advances that research and development (R&D) works in Kuwait undertaken by the Kuwait Institute for Scientific Research (KISR) are detailed to present a comprehensive picture of future integration plans that could stem-out of such research efforts. These will comprise mechanical recycling efforts of polyolefin based polymer waste generated from various households in the state, the development of a product from secondary recycling techniques that could withstand harsh weathering conditions associated with the arid environment of Kuwait; and the thermolysis reaction modelling for plastic film waste, which could provide a plethora of solutions for the thermos-chemical conversion (TCC) of PSW generated from municipal sources. In addition, biodegradable plastic standardisation by studying the exposure of environmental conditions on oxo- and hydro-biodegradable plastics, will be detailed. Finally, TCC efforts utilising a newly registered US Patent & Trademark Office (USPTO) technology is also shown for the chemical valorisation of PSW and end of life tyres (ELTs) using pyrolysis technology with the aim of fuel recovery (C_1-C_4 light hydrocarbons and C_{5+} pyro-oil) from various SW components. With these combined results, the various components that comprise PSW of Kuwait could be valorised to an optimal level using a high-end of pipe solution approach that could pave the way for future development of an integrated approach for managing the waste in the country. This will also reduce various environmental stressors that are now noted to be part of the living environment of Kuwait namely terrestrial and marine systems which are plagued with the accumulation of PSW.

Day 1
Mon 9 Nov

Day 2
Tue 10 Nov

Day 3
Wed 11 Nov

Wed 11 Nov

19:00 - 19:00

Marine litter science: innovative solutions and the role of citizen science

Chair: Dr Fahad Al Senafi

19:00 - 19:20

Citizen science, MCS beach clean programme

Dr. Laura Foster - Marine Conservation Society, UK

19:20 - 19:40

Waste Fishing Gear: Overview, Products and Innovation

Prof. Martin Charter - University for the Creative Arts

19:40 - 20:00

Plastic Consumption, Environmental Pollution and Plastic Waste Exports: Understanding Problems and Developing Solutions

Prof. Stuart Barnes - King's College London, UK

20:00 - 20:05

Kuwait Dive Team: Guardians of the Sea

Dr. Dari Alhuwail - Kuwait Dive Team

20:05 - 20:10

Project OEOO - Frontline action to stop marine plastic pollution in MENA

Sebsatian Frisch - Black Forest Solutions, Germany

20:10 - 20:30

Q&A panel

Appendix B

KEPA Field Assessment Results

Day/Date of Sampling	Location	Coordinates	Collected Debris (by Number)
Monday/18/1/2021	Shwaikh Beach (Medical area)	29° 19' 30.792'' N 47° 53' 16.512'' E	N/A
Monday 25/1/2021	Oshairej Beach	29° 22' 57.2808'' N 47° 50' 2.6052'' E	146
Wednesday 27/1/2021	Judailiat Beach	29° 21' 23.4792'' N 47° 41' 31.7328'' E	123
Thursday 4/2/2021	Kuwait Towers Beach	29° 23' 27.4308'' N 48° 0' 3.2256'' E	167
Monday 8/2/2021	Sulaibikat Beach	29° 19' 8.9004'' N 47° 51' 40.8708'' E	144
Thursday 11/2/2021	Free Trade Zone	29° 21' 7.5276'' N 47° 54' 17.8164'' E	126
Sunday 14/2/2021	Umm Al Nammel Island	29° 22' 56.6292'' N 47° 52' 7.2048'' E	184
Sunday 21/2/2021	Sulaibikat Beach	29° 19' 24.7692'' N 47° 49' 43.9284'' E	107
Tuesday 23/2/2021	Fahaheel Beach	29° 5' 31.7472'' N 48° 8' 18.0852'' E	96
Sunday 14/3/2021	Sulaibikat Beach	29° 19' 8.9004'' N 47° 51' 40.8708'' E	220
Wednesday 17/3/2021	Oshairej Beach	29° 22' 57.2808'' N 47° 50' 2.6052'' E	173
Tuesday 23/3/2021	Doha West	29° 22' 29.8776'' N 47° 45' 10.6992'' E	123