Protecting Marine Life through the Strengthening of Global Plastic Pollution Governance during and after the COVID-19 Pandemic

Fig. 1. (a–d). In Soko Islands, Hong Kong an environmental survey carried out by Marine conservationist NGO group- Oceans Asia found masks washed up on beaches (32).

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Executive summary

The Covid-19 pandemic has led to unprecedented responses worldwide to prevent the spread of the virus, greatly changing daily life globally. Personal Protective Equipment (PPE) is a crucial measure used to reduce the spread of Covid-19, preventing more infections and deaths.

Waste disposal systems have struggled to manage the immense increase in infectious medical waste such as PPE. This, combined with increased levels of litter, has led to PPE found in oceans increasing rapidly.

PPE, a form of marine plastic pollution (MPP), poses risks to all marine life. Risks vary from entanglement of turtles to the ingestion of micro and nanoplastics by sardines. This has had and continues to have devastating impacts on marine life: the deaths of apex predators, the introduction of invasive species and bioaccumulation of microplastics in food chains.

Current governance surrounding PPE pollution in oceans is limited, whilst general MPP governance is weak, patchworked and fails to take strong action.
There is a need for governance proposals that acknowledge the trade-off between the immediate protection of humanity and the protection of planetary health and hence humanity's future. There is an imminent need for the establishment of an international organisation dedicated to the prevention of MPP, to provide a coordinated fight against this ecological crisis. Their action should focus on four main areas: preventing land based sources of MPP, mitigating the impacts of essential plastics, innovating by developing alternatives to current plastics and cooperating between nations.

Key Concept: Planetary Boundaries

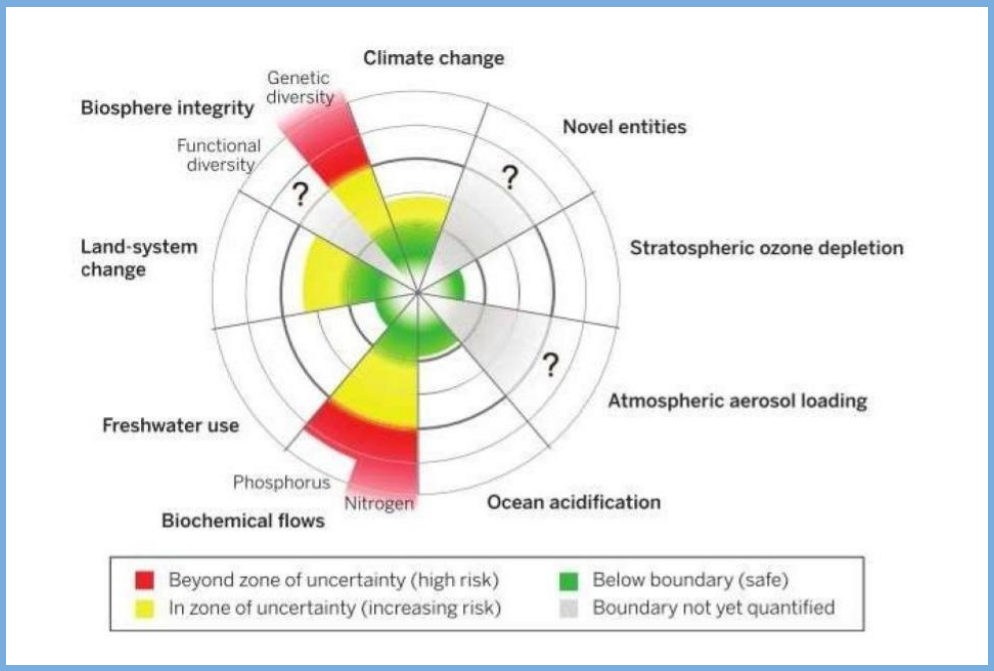

Figure 2: A diagram showing the Planetary Boundaries (33)

Planetary boundaries are estimations of levels of risk to the Earth system from anthropogenic actions (33). They can interact with each other, reducing the resilience of other boundaries, increasing the risk of triggering an unstable Earth system.

Foundational Science: Discussion and Analysis

The Covid-19 pandemic has led to a large increase in the use of Personal Protective Equipment (PPE) globally. The use of facemasks by the general public was recommended by the World Health Organisation (WHO) in 2020 as they reduce transmission of Covid-19 (34). This has increased PPE found on beaches (5,9,10,20) from both litter directly on beaches and PPE that has entered the oceans. With single-use facemasks being made from non-renewable, petroleum-based polymers, the risks posed are similar to those from other forms of Marine Plastic Pollution (MPP). These have devastating impacts on both marine life and humans relying on oceans for its ecosystem services (fig 5).

Figure 3 shows the two main ways that MPP enters oceans. PPE most commonly reaches oceans from land-based activities, posing varied risks towards marine life when in different stages of its degradation. The most widely mandated and used PPE however is single-use facemasks made from plastic. Once in oceans, they can exist as large pieces of plastics in the sea risking entanglement and ingestion by marine life. As marine species ingest the larger PPE items, they are degraded into microplastics and nanoplastics, posing further risks to marine life. Figure 4 shows the different types of MPP that PPE can be broken down into and some risks they pose to marine life.

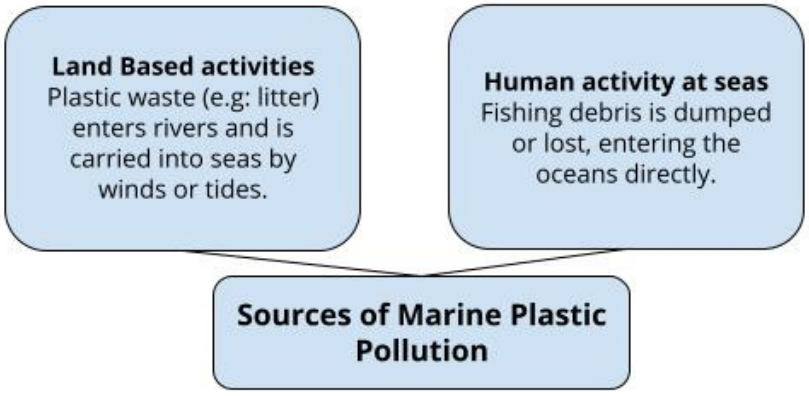

Figure 3: A diagram showing the different sources of MPP, constructed with information from (25)

Type of MPP	Large Pieces of Plastics	Microplastics	Nanoplastics
Size	>5mm	1-5mm	<1mm
Risks to marine life	Entanglement	Ingestion	Ingestion

Figure 4: A table showing different types of MPP, using information from (26, 28)

One risk to marine biodiversity is the bioaccumulation of microplastics, with fig 6 showing bioaccumulation through food chains. At 1, microplastics within shrimp and plankton are ingested by the larger fish at 2. This larger fish accumulates microplastics within them which are broken down further into nanoplastics within the fish. These larger fish then consume the smaller fish in large amounts. Humans- the apex predator- then consume the larger fish containing a high concentration of microplastics within them (25, 26, 28).

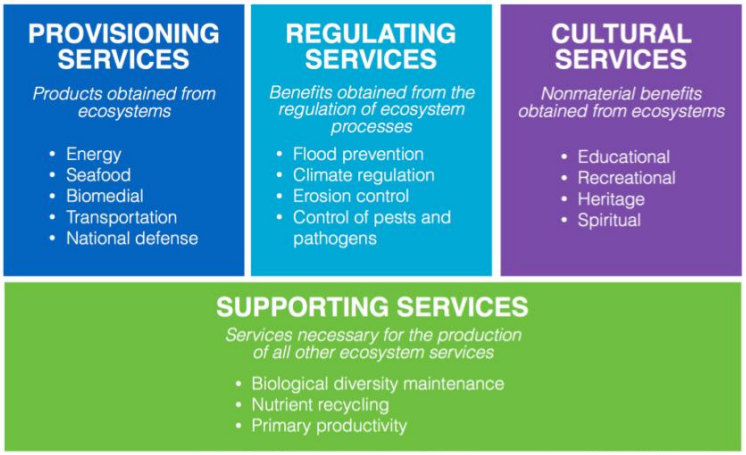

Figure 5: A chart showing the different ecosystem services offered by oceans (39)

The risks posed to marine life and humans from ingesting microplastics from PPE are largely unknown, however general risks of microplastics can be used as an indicator. One risk is a reduction in reproduction rates of marine species, decreasing growth rates (13). This has the potential to cause trophic cascades as falling reproduction rates of species ingesting reduces prey for predators to survive on. This decreases growth rates of predators in the ocean as they are forced to compete, hence reducing predators further up the food chain with the potential risk of removing a keystone species. This reduces genetic diversity for the species and has secondary impacts on ecosystems as functional diversity also falls.

The degradation of ocean ecosystems from MPP such as PPE entering oceans decreases the ability of oceans to provide important ecosystem services, such as those shown in fig 5, with PPE bringing invasive species into oceans (1,6), leaching toxic chemicals (7), disrupting food chains and reducing biodiversity. Planetary boundaries can influence each other (33) with a loss of biodiversity in oceans increasing ocean acidification. This means oceans are unable to sequester as much carbon impacting further planetary boundaries. Keeping within the planetary boundaries is necessary to keep the Earth system stable and habitable for humanity.

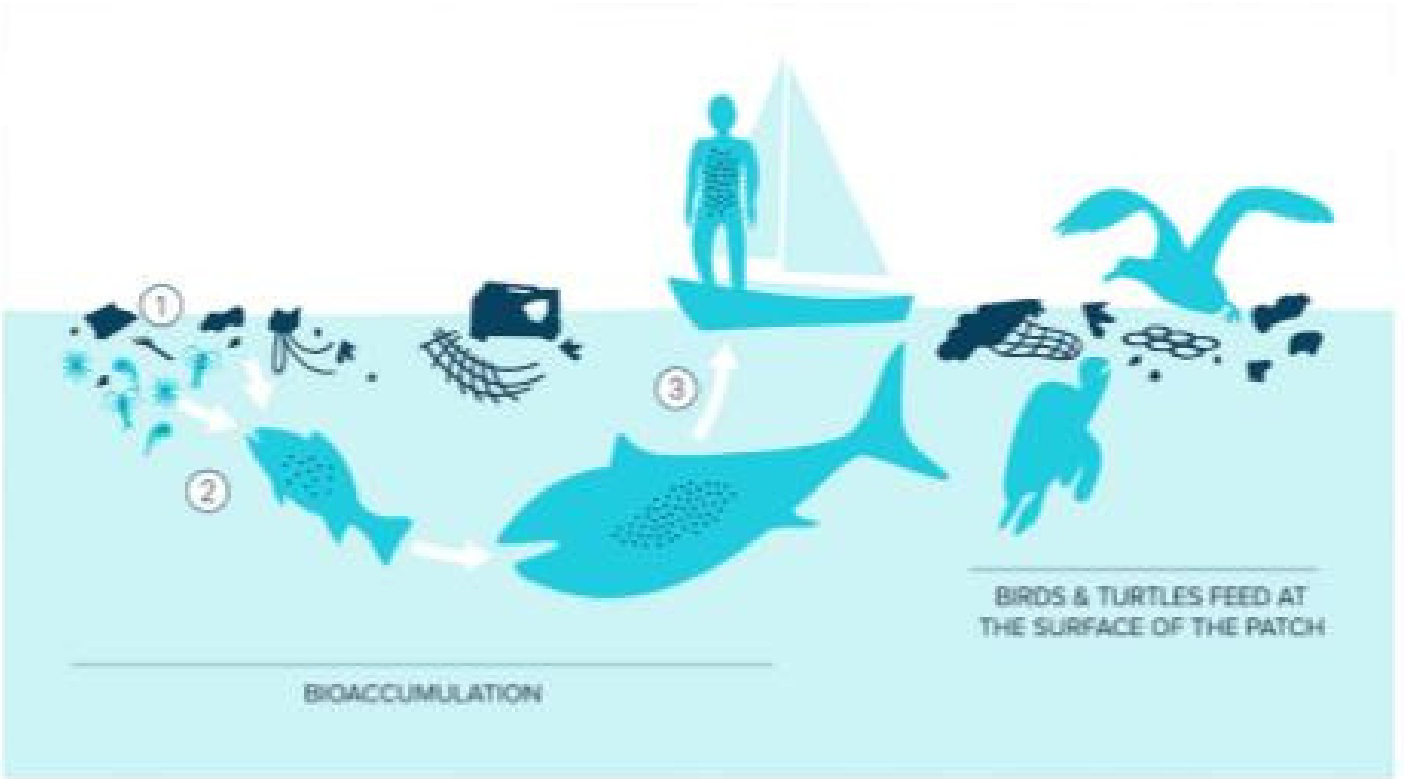

Figure 6: A diagram showing bioaccumulation of microplastics in ocean food chains (40)

Assessment of existing governance

Current global governance recommends using PPE due to evidence that it can reduce Covid-19 transmission (34). Global governance faces a trade-off between saving lives immediately from the Covid-19 pandemic and preventing potentially catastrophic future environmental degradation.

The impact on marine life from the large increase in medical waste from both hospitals treating large numbers of infected patients and the general public seeking to protect themselves has been largely ignored by governments globally.
Current guidance from the United Nations Environment Program (UNEP) on the disposal of PPE is limited to examining the viability of current waste systems for managing Covid-19 related medical waste, adding stop-gap solutions where necessary (36). UNEP emphasise a need to reduce the amount of waste reaching oceans however they do not offer guidance or examples to be followed.

Owing to the infectious nature of PPE, there is little guidance from UNEP on how to recycle PPE nor is there discussion of the impact of high consumption of single-use plastic PPE on both the climate and ocean environments.

This lack of consideration for PPE undermines the *'war on ocean plastic'* declared by UNEP aiming to eliminate single-use plastic by 2022 (35). This campaign focuses on single-use plastics (e.g: plastic bags, straws and microbeads) so naturally should include PPE too.

Although specific PPE related guidance is lacking, PPE is a form of marine plastic pollution, so global governance surrounding MPP applies too.
Current MPP governance (fig 7) is limited and weak. Governance across national, regional and global scales are disorganised, with UNEP themselves describing *'fragmented and uncoordinated'* efforts at an international level (37).

Scale	Regulation
Global	United Nations Convention on the Law of the Sea (UNCLOS)
	London Dumping Convention/ International Convention for the Prevention of Pollution from Ships (MARPOL)
	Global Partnership on Marine Litter (GPML)
	The Honolulu Strategy
	Stockholm Convention on Persistent Organic Pollutants
	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
	The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
Regional	Marine Strategy Framework Directive (MSFD)
	Regional Action Plan on Marine Litter management (RAPMaLi)
	Single-Use Plastics Directive
National	Indonesia's Plan of Action on Marine Plastic Debris for 2017-2025
	Microbead-Free Waters Act

Figure 7: Examples of regulatory initiatives captured by governance scale (26)

One of the earlier global treaties that attempted to address marine pollution through international cooperation is the United Nations Convention on the Law of the Sea (UNCLOS) (26). UNCLOS sets out a legal framework for global ocean governance, focussing mainly on ships and their pollution. It does not explicitly target land-based sources of marine plastic pollution despite it accounting for approximately 80% of marine litter (38). In the present day, this is essential given the amount of plastic now in the oceans since UNCLOS was established.

Prior to the pandemic, global MPP governance was concerning, it is now largely inadequate, failing to account for the large amounts of land-based MPP and ignoring PPE.

Governance Recommendations

Globally, PPE use must continue as a norm to contain the pandemic. Although countries with high levels of vaccination may remove mask mandates, the global vaccination rollout has been unequal and many countries will continue to be impacted by Covid-19 in the future.

The establishment of a new authority on marine plastic pollution is essential for facing this crisis. They would begin by implementing governance initiatives that combine interventions at different points in the lifecycle of PPE, with the eventual aim of a circular economy where single-use PPE is recycled through pyrolysis.

The recommended governance initiatives fall into four categories: *Cooperation, Prevention, Mitigation* and *Innovation*.

*'The **scale** and **complexity** of the issue is too grand to be managed by individuals, specific industries, or countries **in isolation'** (28)*

Cooperation

- Establishment of a centre of authority on Marine Plastic Pollution. Both IPBES and UNEP exist currently but there is a need for a coordinated effort (26). A new organisation could bring together international organisations, firms and governments to construct new binding laws.
- Using a Montreal Protocol model to tackle the problem of MPP (25, 26, 27). This would be difficult due to the lack of alternatives to plastic currently. However, hard legally binding treaties similar to the Montreal Protocol are essential. These should seek to close the loop for PPE and MPP more generally and pay attention to land-based sources of MPP.
- The introduction of Global Extended Polluter Responsibility. This is an extension of the Polluter Pays Principle introduced into international environmental law in 1992. It seeks to make producers responsible for their product at the end of its life, sorting products that have become waste so that they can receive appropriate treatment (27). This could be implemented through the introduction of global plastic design standards which firms must meet or face sanctions. This would have a financial burden for firms so the implementation must be complemented by a financial aid scheme for firms transitioning.

Mitigation

- Current PPE disposal commonly involves incineration (8, 9). Improving the environmental viability of current waste disposal systems globally by increasing the share of power used for waste incineration which comes from renewable sources is essential to mitigate further environmental harm from the disposal of PPE.
- Encouragement of firms to increase feedstock recycling. Processes like pyrolysis and gasification can be used to break down long polymer chains found in PPE into shorter ones. These can then be used to make new polymers. Thie new organisation could get nations to offer financial incentives, rewarding firms with high amounts of feedstock recycling or by introducing legislation mandating that feedstock recycling must take place for their PPE waste (4,6).

Prevention

- Educational campaigns: Countries must implement educational campaigns to decrease PPE littering. A balance must be struck between encouraging the use of PPE to protect against Covid-19 but also encouraging responsible consumption and disposal of PPE. Campaigns can and should go beyond PPE litter, aiming to generally reduce the common misconception that recycled or reusable items are unhygienic as the pandemic has encouraged single-use plastic past what is necessary to prevent the spread of Covid-19 (22, 31).
- This could take place in countries at a national level through advertising and educational campaigns surrounding littering in schools. The implementation of microbead bans across the globe stemmed from increased consumer awareness putting pressure on governments.
- Educational campaigns also do not have to occur at only a national level: IPBES and UNEP both have the global influence to introduce global campaigns which complement national campaigns.
- Complementing educational campaigns at a national level, rewarding positive PPE recycling behaviour potentially offering incentives (such as vouchers) to citizens returning their PPE to recycling points. Evidence that rewarding positive behaviour is able to increase recycling rates (26). This could be linked to pyrolysis in the *Mitigation* stage.

Innovation

- The new organisation should fund further investigation into how shredded used face masks can be an effective base for pavements and for reinforcing concrete (8, 9). If further research is successful, the new organisation should work with nations to implement their own PPE recycling programs where shredded PPE waste is used to improve and replace existing infrastructure.
- There is a need for a global transition towards bioplastics (21) Research into this could be funded through grants from the new MPP focused organisation. Bioplastics would be beneficial as they would not break down into hazardous microplastics and would instead biodegrade. This would be a move towards a circular economy in which PPE waste can be used to make new products. The *Prevention* recommendations, however, are still necessary as not all bioplastics are marine biodegradable.

Reference list

(1) Liang Y, Song Q, Wu N, Li J, Zhong Y, Zeng W. Repercussions of COVID-19 pandemic on solid waste generation and management strategies. Front Environ Sci Eng 2021;15(6).
(2) Das AK, Islam MN, Billah MM, Sarker A. COVID-19 pandemic and healthcare solid waste management strategy – A mini-review. Sci Total Environ 2021;778.
(3) Alfonso MB, Arias AH, Menéndez MC, Ronda AC, Harte A, Piccolo MC, et al. Assessing threats, regulations, and strategies to abate plastic pollution in LAC beaches during COVID-19 pandemic. Ocean Coast Manage 2021;208.
(4) Dharmaraj S, Ashokkumar V, Pandiyan R, Halimatul Munawaroh HS, Chew KW, Chen W-, et al. Pyrolysis: An effective technique for degradation of COVID-19 medical wastes. Chemosphere 2021;275.
(5) da Costa JP. The 2019 global pandemic and plastic pollution prevention measures: Playing catch-up. Sci Total Environ 2021;774.
(6) De-la-Torre GE, Rakib MRJ, Pizarro-Ortega CI, Dioses-Salinas DC. Occurrence of personal protective equipment (PPE) associated with the COVID-19 pandemic along the coast of Lima, Peru. Sci Total Environ 2021;774.
(7) Dharmaraj S, Ashokkumar V, Hariharan S, Manibharathi A, Show PL, Chong CT, et al. The COVID-19 pandemic face mask waste: A blooming threat to the marine environment. Chemosphere 2021;272.
(8) Saberian M, Li J, Kilmartin-Lynch S, Boroujeni M. Repurposing of COVID-19 single-use face masks for pavements base/subbase. Sci Total Environ 2021;769.
(9) Kilmartin-Lynch S, Saberian M, Li J, Roychand R, Zhang G. Preliminary evaluation of the feasibility of using polypropylene fibres from COVID-19 single-use face masks to improve the mechanical properties of concrete. J Clean Prod 2021;296.
(10) Cordova MR, Nurhati IS, Riani E, Nurhasanah, Iswari MY. Unprecedented plastic-made personal protective equipment (PPE) debris in river outlets into Jakarta Bay during COVID-19 pandemic. Chemosphere 2021;268.
(11) Ardusso M, Forero-López AD, Buzzi NS, Spetter CV, Fernández-Severini MD. COVID-19 pandemic repercussions on plastic and antiviral polymeric textile causing pollution on beaches and coasts of South America. Sci Total Environ 2021;763.
(12) Hartanto BW, Mayasari DS. Environmentally friendly non-medical mask: An attempt to reduce the environmental impact from used masks during COVID 19 pandemic. Sci Total Environ 2021;760.
(13) Parashar N, Hait S. Plastics in the time of COVID-19 pandemic: Protector or polluter? Sci Total Environ 2021;759.
(14) De-la-Torre GE, Aragaw TA. What we need to know about PPE associated with the COVID-19 pandemic in the marine environment. Mar Pollut Bull 2021;163.
(15) Haque MS, Uddin S, Sayem SM, Mohib KM. Coronavirus disease 2019 (COVID-19) induced waste scenario: A short overview. J Environ Chem Eng 2021;9(1).
(16) Patrício Silva AL, Prata JC, Walker TR, Duarte AC, Ouyang W, Barcelò D, et al. Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations. Chem Eng J 2021;405.
(17) Ammendolia J, Saturno J, Brooks AL, Jacobs S, Jambeck JR. An emerging source of plastic pollution: Environmental presence of plastic personal protective equipment (PPE) debris related to COVID-19 in a metropolitan city. Environ Pollut 2021;269.
(18) Rowan NJ, Laffey JG. Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic – Implications for efficacy, re-use and sustainable waste management. Sci Total Environ 2021;752.
19) Issac MN, Kandasubramanian B. Effect of microplastics in water and aquatic systems. Environ Sci Pollut Res 2021.

((20) Haque MS, Sharif S, Masnoon A, Rashid E. SARS-CoV-2 pandemic-induced PPE and single-use plastic waste generation scenario. Waste Manage Res 2021.
(21) Okuku E, Kiteresi L, Owato G, Otieno K, Mwalugha C, Mbuche M, et al. The impacts of COVID-19 pandemic on marine litter pollution along the Kenyan Coast: A synthesis after 100 days following the first reported case in Kenya. Mar Pollut Bull 2021;162.
(22) Vanapalli KR, Sharma HB, Ranjan VP, Samal B, Bhattacharya J, Dubey BK, et al. Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic. Sci Total Environ 2021;750.
(23) De Sousa FDB. Pros and cons of plastic during the COVID-19 pandemic. Recycl 2020;5(4):1-17.
(24) Ortiz AA, Sucozhañay D, Vanegas P, Martínez-Moscoso A. A regional response to a global problem: Single use plastics regulation in the countries of the pacific alliance. Sustainability 2020;12(19):1-21.
(25) Ferraro G, Failler P. Governing plastic pollution in the oceans: Institutional challenges and areas for action. Environ Sci Policy 2020;112:453-460.
(26) Black JE, Holmes DE, Carr LM. A geography of marine plastics. Ir Geogr 2020;53(1):59-92.
(27) Raubenheimer K, Urho N. Rethinking global governance of plastics – The role of industry. Mar Policy 2020;113.
(28) Mæland CE, Staupe-Delgado R. Can the Global Problem of Marine Litter Be Considered a Crisis? Risk, Hazards Crisis Public Policy 2020;11(1):87-104.
(29) Pan Y, Zhang B, Wu Y, Dai F, Tian Y. The latest developments of IPBES and China's countermeasures. Biodivers Sci 2020;28(10):1286-1291.
(30) Wu Y, Pan Y, Zhang B, Dai F, Tian Y. Regional assessment on biodiversity and ecosystem services and policy experience within the IPBES framework. Biodivers Sci 2020;28(7):913-919.
(31) Makki F, Lamb A, Moukaddem R. Plastics and the coronavirus pandemic: a behavioral science perspective. Mind Soc 2020.
(32) OceansAsia. Masks on the Beach [Internet]. OceansAsia; 2020. Available from: https://oceansasia.org/wp-content/uploads/2020/12/Marine-Plastic-Pollution-FINAL-1.pdf
(33) ROCKSTRÖM J. Planetary Boundaries. New Perspectives Quarterly. 2010;27(1):72-74.
(34) World Health Organisation. Mask use in the context of COVID-19 [Internet]. WHO; 2020. Available from: https://www.who.int/publications/i/item/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-(2019-ncov)-outbreak
(35) UN Declares War on Ocean Plastic [Internet]. UN Environment. 2017 [cited 24 March 2021]. Available from: https://www.unep.org/news-and-stories/press-release/un-declares-war-ocean-plastic-0
(36) Introduction to Covid-19 Waste Management [Internet]. Wedocs.unep.org. 2021 [cited 26 March 2021]. Available from: https://wedocs.unep.org/bitstream/handle/20.500.11822/32282/COVIDWM.pdf?sequence=1&isAllowed=y
(37) United Nations Environment Assembly of the United Nations Environment Programme. Combating marine plastic litter and microplastics: An assessment of the effectiveness of relevant international, regional and subregional governance strategies and approaches [Internet]. Nairobi; 2017. Available from: https://www.researchgate.net/publication/346487759_Combating_marine_plastic_litter_and_microplastics_an_assessment_of_the_effectiveness_of_relevant_international_regional_and_subregional_governance_strategies_and_approaches
(38) Jambeck J, Geyer R, Wilcox C, Siegler T, Perryman M, Andrady A et al. Plastic waste inputs from land into the ocean. Science. 2015;347(6223):768-771.
(39) The White House Council on Environmental Quality. Final Recommendations Of The Interagency Ocean Policy Task Force. 2010.
(40) The Great Pacific Garbage Patch [Internet]. The Ocean Cleanup. 2021 [cited 4 May 2021]. Available from: https://theoceancleanup.com/great-pacific-garbage-patch/