On the water cycles of the earth with respect to plastic pollution and climate change.
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THE hydrological cycle, including precipitation, evaporation, freezing and melting, is an incessant process intimately linked with energy exchanges among the atmosphere, oceans, and land which determines earth's climate plus its variabilities and thus being at the core of both the causes and effects of climate change. Regarding the global evaporations from the oceans, the greenhouse effect is linked to this process, as it cools the surfaces of the ocenas and thence partly buffers the greenhouse effect from the increasing amount of carbon dioxide and other gases[1]. Impacts of the latter are probable to influence water planning as well as changes in water demands, as irrigation water demands are especially sensitive to changes in precipitation, temperature, and carbon dioxide levels[2].

With the increase of plastic waste in the marine environment, its effects are bound to become an influential aspect of the atmosphere's greenhouse gas concentration. Microplastics are widely incorporated in earth's water cycles originating from both land-based and marine sources. Concerning ocean plastics, the best estimates suggest that approximately 80 percent come from land-based sources[3] while other estimates assign marine sources a slightly higher level of contribution, at around 28 percent[4] of which an estimated half arises from fishing fleets[5]. Apart from the totality of global sources, the

[1]NASA SCIENCE *SHARE THE SCIENCE* 2021, "Water Cycle", NASA SCIENCE *SHARE THE SCIENCE*, viewed 29 May 2021. https://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle

[2]Ragab Ragab, Christel Prudhomme, "SW—Soil and Water: Climate Change and Water Resources Management in Arid and Semi-arid Regions: Prospective and Challenges for the 21st Century", *Biosystems Engineering*, Volume 81, No 1, 2002

[3]W.C. LI, H.F. TSE, L. FOK, "Plastic waste in the marine environment: A review of sources, occurrence and effects", *Science of The Total Environment*, Volume 566-567, 2016, p. 333-349

[4]Lebreton, L., Slat, B., Ferrari, F. et al., "Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic", *Sci Rep* 8, 4666 (2018). https://doi.org/10.1038/s41598-018-22939-w

[5]Macfadyen, G.; Huntington, T.; Cappell, R., "Abandoned, lost or otherwise discarded fishing gear.", *UNEP Regional Seas Reports and Studies*, No. 185; $FAOFisheriesandAquacultureTechnicalPaper$, No. 523. Rome, UNEP/FAO, 2009, p. 115

relative contribution of different sources varies significantly depending on geographic location and context, as e.g., the plastic mass in the "Great Pacific Garbage Patch" consists of 52 percent plastic lines, ropes and fishing nets[6].

Plastic materials experience extensive usage in fisheries owing to their durability and extremely slow rate of biodegradation. Therefore, procedures for minimization of plastic waste originating from abandoned, lost, or discarded fishing gear need to be adopted. In addition, strict compliance of MARPOL regulations for safe disposal of rubbish, oil, oily mixtures, and other residues originating from fishing vessel operations need to be promoted and implemented[7].

Furthermore, the annual production of plastics has increased 200-fold from the 1950s to 2014, posing a risk to organisms as microplastics can lead to absorption of hydrophobic contaminants which then have the potential to bioaccumulate in the food chain[8].

In fact, GHG emissions occur from the cradle to the grave of plastic, including raw material exploitation and transportation, manufacturing processes, waste treatment and the entering of the environment. With oil and gas industries being the main sources of GHG emissions respecting the first two categories mentioned before, global emissions of the plastic life cycle are predicted to reach 1.34 Gt per year by 2030 and might have exceeded 2.8 Gt per year by 2050, while the accumulating emissions may have exceeded 56 Gt by that time. Plastics in the environment release greenhouse gases and microplastic accumulations in the earth's oceans will significantly interfere with their carbon fixation capacity[9]. Such an interference can be elucidated by regarding a natural process of one particular food chain influenced by human beings. Marine algae that absorb carbon dioxide are consumed by small creatures with gelatinous bodies called salps, which deposit the CO_2 in their faecal pellets. These are normally heavy enough to sink to the ocean floor, preventing the CO_2 from reaching the atmosphere and instead causing it to be dissolved in the water. But with the influence of microplastics, the faecal pellets become lighter and more buoyant, leading to an increase in the duration of them floating on the surface of the water, resulting in a reabsorption of the CO_2 into the atmosphere. Consequently, microplastics have the potential to lower the efficiency of the ocean's carbon dioxide sequestration process[10].

[6]Lebreton, L., Slat, B., Ferrari, F. et al., "Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic", *Sci Rep* 8, 4666 (2018). https://doi.org/10.1038/s41598-018-22939-w

[7]M.R. Boopendranath, "M.R. Boopendranath", *Central Institute of Fisheries Technology, P.O. Matsyapuri, Cochin - 682 029, India*, 49, 2012, p. 109- 119

[8]W.C. LI, H.F. TSE, L. FOK, "Plastic waste in the marine environment: A review of sources, occurrence and effects", *Science of The Total Environment*, Volume 566-567, 2016, p. 333-349

[9]Maocai Shen, Wei Huang, Ming Chen, Biao Song, Guangming Zeng, Yaxin Zhang, "(Micro)plastic crisis: Un-ignorable contribution to global greenhouse gas emissions and climate change", *Journal of Cleaner Production*, Volume 254, 2020

[10]Chrissy Sexton 2019, "Microplastics are interfering with natural carbon storage in the ocean", Chrissy Sexton, viewed 29 May 2021. https://www.earth.com/news/microplastics-natural-carbon-storage/