Towards Healthy Ecosystems: Addressing Plastic Pollution for Sustainability

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Kariuki Muigua

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Kariuki Muigua*

Abstract

Burning, landfilling, and incineration of plastic waste pollutes the environment and costs money. The worldwide buildup of plastic pollution exceeds 8.3 billion metric tonnes since 1950. Home plastic waste has increased because to the COVID-19 epidemic, causing a global waste management catastrophe. Synthetic oil byproduct plastics are affordable, durable, lightweight, flexible, stiff, vivid, moldable, and resistant to high temperatures, corrosion, UV radiation, and chemicals.

Africa is the second most polluted continent, importing about 500 garbage cargo containers weekly. Plastic garbage costs USD 13 billion annually in tourism, leisure, and fishing. To mitigate the social and environmental impacts of poorly managed plastic garbage, sustainable development must be prioritized. In 2017, Kenya outlawed the use, production, and importation of all commercial and home plastic bags. Exempt were medical garbage, construction, food packaging, and trash bin liners. Single-use plastic bags dropped 80% after the ban.

The restriction helped, but the nation still faces plastic pollution from other sources. This article shows the negative consequences of plastic pollution on human health and the ecosystem and contributes to sustainability literature on how best to address this pollution challenge.

1. Introduction

Plastic garbage is being released into the environment at an alarming pace due to excessive manufacturing, incorrect landfill disposal, and insufficient recycling.[1] This is

PhD in Law (Nrb), FCIArb (Chartered Arbitrator), LL. B (Hons) Nrb, LL.M (Environmental Law) Nrb; Dip. In Law (KSL); FCPS (K); Dip. In Arbitration (UK); MKIM; Mediator; Consultant: Lead expert EIA/EA NEMA; BSI ISO/IEC 27001:2005 ISMS Lead Auditor/ Implementer; Advocate of the High Court of Kenya; Prof. at the University of Nairobi, Faculty of Law [June, 2024].

[1] Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P.K., Kumar, R., Kumar, P., Shubham, Das, S. and Sharma, P., 2021. Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability*, *13*(17), p.9963.

causing major difficulties for the expanding populations of emerging nations.[2] The exponential increase in population has a direct impact on the abundance of plastic garbage, ultimately leading to environmental contamination.[3] The buildup of plastic garbage is a substantial worldwide problem, since conventional practices like open burning, landfilling, and incineration result in the release of greenhouse gases and economic losses.[4] Since 1950, the global accumulation of plastic pollution is estimated to exceed 8.3 billion metric tonnes, mostly driven by advancements in technology.[5] Due to the COVID-19 pandemic, there has been a significant surge in plastic trash generated at home, resulting in a worldwide crisis in waste management.[6] Inadequate handling of plastic garbage may have a detrimental effect on the environment, as well as the animals and organisms that live in it.[7]

Plastics, originating from the Greek term "plastikos," are organic compounds composed of complex molecules, mostly produced from synthetic oil byproducts.[8] These materials

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[2] Ibid.

[3] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233; Pilapitiya, P.N.T. and Ratnayake, A.S., 2024. The world of plastic waste: a review. *Cleaner Materials*, p.100220; Alabi, O.A., Ologbonjaye, K.I., Awosolu, O. and Alalade, O.E., 2019. Public and environmental health effects of plastic wastes disposal: a review. *J Toxicol Risk Assess*, *5*(021), pp.1-13.

[4] Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637.

[5] Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637; Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

[6] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

[7] Ibid.

[8] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233; Ilyas, M., Ahmad, W., Khan, H., Yousaf, S., Khan, K. and Nazir, S., 2018. Plastic waste as a significant threat to environment–a systematic literature review. *Reviews on environmental health*, *33*(4), pp.383-406.

are cost-effective, easy to use, very durable, lightweight, flexible, stiff, vibrant, moldable, and capable of withstanding high temperatures, corrosion, UV radiation, and chemical exposure.[9] Their characteristics differ mainly as a result of their origin, manufacturing procedure, or additions. Plastics are categorized into four groups: natural, semi-synthetic, bioplastics, and virgin or synthetic plastics.[10]

Manufacturing has outpaced other sectors in terms of growth, and Africa is now the second most polluted continent globally, with a monthly import of over five hundred cargo containers filled with waste.[11] The yearly economic impact of plastic trash amounts to around USD 13 billion, including losses in tourist revenue resulting from reduced visual appeal, diminished recreational opportunities, and negative effects on fishing activities.[12] It is crucial to prioritize sustainable development objectives in order to address and reduce the social and environmental consequences of poorly managed plastic trash.[13]

It is worth noting that Kenya Plastic Bag Ban effected through Gazette Notice No. 2356 dated February 28, 2017 and issued under the Environmental Management and Co-ordination Act (Plastic Bag Ban on Secondary Packaging), with effect from 6 months from the date of this notice banned the use, manufacture and importation of all plastic bags used for commercial and household packaging defined as follows: (a) Carrier bag—bag constructed with handles, and with or without gussets; (b) Flat bag— bag constructed

[9] Ibid.; Ilyas, M., Ahmad, W., Khan, H., Yousaf, S., Khan, K. and Nazir, S., 2018. Plastic waste as a significant threat to environment–a systematic literature review. *Reviews on environmental health*, *33*(4), pp.383-406.
[10] Ibid.
[11] Ibid.; Pandey, P., Dhiman, M., Kansal, A. and Subudhi, S.P., 2023. Plastic waste management for sustainable environment: techniques and approaches. *Waste Disposal & Sustainable Energy*, *5*(2), pp.205-222.
[12] Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637.
[13] Ibid.

without handles, and with or without gussets.[14] Medical trash, construction, food packaging, and rubbish bin liners were exempt. Plastic bag manufacturers and users risk up to four years in prison or a $40,000 (4.4 million Kenyan shillings) fine, among of the worst punishments in the world.[15] Earlier efforts to ban these plastic bags failed, but this ban worked, even though the Kenyan Association of Manufacturers complained.[16] The use of single-use plastic bags dropped by 80%.[17] Support from the people and involvement of stakeholders are big parts of success.[18] This was followed by a number of related policies. The Ministry of Tourism and Wildlife also issued official notice No. 4858 on June 6, 2019, about a ban on single-use plastics in protected areas starting June 5, 2020.[19] Despite this ban and the associated success, the country is still struggling with the problem as well as other non-banned sources of plastic pollution.[20]

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[14] Republic of Kenya, Gazette Notice No. 2356, *the Kenya Gazette,* Vol.CXIX-No.31, Page. 1077, 14 March,2017. Available at http://kenyalaw.org/kenya_gazette/gazette/notice/181293

[15] 'Kenya Plastic Bag Ban Notice No. 2356 - The Environmental Management and Co-ordination Act (Plastic Bag Ban on Secondary Packaging)' (no date) *Global Plastics Policy Centre*. Available at: https://plasticspolicy.port.ac.uk/policy-reviews/kenya-plastic-bag-ban/ (Accessed: 11 June 2024).

[16] Ibid.

[17] Kimeu C, 'After a Plastic Bag Ban, Kenya Takes Another Shot at Its Pollution Problem' *The Guardian* (30 May 2023) <https://www.theguardian.com/global-development/2023/may/30/kenya-wrestles-with-its-plastic-pollution-problem> accessed 11 June 2024.

[18] Ibid.; *National Environment Management Authority (NEMA) - Judges upholds plastic bags ban* (no date). Available at: https://www.nema.go.ke/index.php?option=com_content&view=article&id=225:judges-upholds-plastic-bags-ban&catid=10:news-and-events&Itemid=375 (Accessed: 11 June 2024).

[19] *Policies, Laws & Regulations* (2024) *Conservation Alliance of Kenya*. Available at: https://www.conservationalliance.or.ke/resources/policies-laws (Accessed: 11 June 2024).

[20] *The return of single-use plastics six years after ban* (2023) *Nation*. Available at: https://nation.africa/kenya/health/the-return-of-single-use-plastics-six-years-after-ban-4258862 (Accessed: 11 June 2024); Macharia, D.A. (2019) 'Current status on dealing with plastics in Kenya', *Mazingira Safi*, 18 December. Available at: https://www.mazingirasafi.com/current-status-on-dealing-with-plastics-in-kenya/ (Accessed: 11 June 2024); week, S. up to date on the editors' picks of the (2020) *Plastic ban a major step in achieving green economy goals*, *Business Daily*. Available at: https://www.businessdailyafrica.com/bd/opinion-analysis/columnists/plastic-ban-a-major-step-in-achieving-green-economy-goals-2169460 (Accessed: 11 June 2024).

This paper highlights the adverse effects of plastic pollution on not only human health but also the environment in general and also adds to the existing literature on how the problem can be effectively addressed to sustainability.

2. Plastic Pollution Control: Challenges and Prospects

The exponential surge in plastic trash has resulted in a catastrophic impact on the environment, as the demand for plastic continues to grow each year.[21] The extensive exploitation, disregard, non-biodegradable characteristics, and physical and chemical features of plastic trash have led to a significant pollution burden on the environment.[22] Plastic infiltrates the food chain and may result in severe health complications for both aquatic creatures and people.[23]

The deterioration of plastic garbage and its social implications are substantial concerns that need attention.[24] Inadequate management of manufacture, utilisation, and disposal practices results in the depletion of finite resources, environmental issues, climate change, and detrimental effects on the survival of plant and animal life.[25]

Plastic polymers are classified based on their environmental toxicity, which might harm the organisms living in their vicinity.[26] The majority of plastic trash is disposed of by

[21] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.
[22] Pandey, P., Dhiman, M., Kansal, A. and Subudhi, S.P., 2023. Plastic waste management for sustainable environment: techniques and approaches. *Waste Disposal & Sustainable Energy*, *5*(2), pp.205-222; Evode, N., Qamar, S.A., Bilal, M., Barceló, D. and Iqbal, H.M., 2021. Plastic waste and its management strategies for environmental sustainability. *Case Studies in Chemical and Environmental Engineering*, *4*, p.100142.
[23] Ibid.
[24] Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637.
[25] Ibid.
[26] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

incineration, landfilling, littering, or recycling after it is no longer functional, which leads to the release of carbon or methane emissions over a period of time.[27] In order to mitigate the accumulation of garbage in landfills, stakeholders and governments are striving to minimise the quantity of waste generated.[28]

The challenges of recycling wasted plastic include insufficient infrastructure for collecting and processing plastic trash, intricate recycling procedures, limited economic benefits, and a lack of sufficient end-users for the recycled plastic.[29] The low cost of crude oil incentivizes the manufacturing of new plastic from virgin materials, making it cheaper than recycling.[30] This results in a low rate of recycling, highlighting the significant shortcomings of the conventional "take, make, and discard" approach.[31]

Recycling, recovering, and reuse are more effective methods for mitigating the wastage of raw materials and the excessive exploitation of resources.[32] To encourage the use of the recycling system and reduce the waste of raw materials, it is necessary to implement long-

[27] Ibid.; Ilyas, M., Ahmad, W., Khan, H., Yousaf, S., Khan, K. and Nazir, S., 2018. Plastic waste as a significant threat to environment–a systematic literature review. *Reviews on environmental health*, *33*(4), pp.383-406.

[28] Ibid.

[29] Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637.

[30] Ibid.; Kiernan, G. (2020) *The Price of Oil, The Cost to Plastic*, *Pakire Polymers*. Available at: https://pakirepolymers.com/the-price-of-oil-the-cost-to-plastic/ (Accessed: 11 June 2024); Foster, L. (no date) *Plastic Is Choking the World. Why People Are Using More of It.*, *barrons*. Available at: https://www.barrons.com/articles/cheap-new-plastic-choking-the-world-9b318936 (Accessed: 11 June 2024); Basham, K. (2019) *How Oil Prices affect Plastic Recycling*, *Plastic Expert*. Available at: https://www.plasticexpert.co.uk/oil-prices-plastic-recycling/ (Accessed: 11 June 2024); Kramer, S. (no date) *The one thing that makes recycling plastic work is falling apart*, *Business Insider*. Available at: https://www.businessinsider.com/low-oil-prices-hurt-plastics-recycling-2016-4 (Accessed: 11 June 2024).

[31] Ibid.

[32] Ibid.; David, A., Thangavel, Y.D. and Sankriti, R., 2019. Recover, recycle and reuse: An efficient way to reduce the waste.

term solutions such as open-loop and closed-loop systems.[33] The issue of wasted plastic may be mitigated by technological innovation, however, it is crucial to also consider the sustainability of these innovations and their application.[34]

2.1. Marine litter and plastic pollution

The current global strategies to tackle plastic pollution are inadequate in effectively resolving the issue.[35] Existing legislative measures prohibiting the disposal of plastic garbage in the ocean, as well as volunteer initiatives and collaborations involving many stakeholders focused on waste management and marine litter, have not proven effective in sufficiently decreasing the quantity of plastic debris that ends up in the marine ecosystem.[36]

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[33] Ibid.; *5.2. Recycling: open-loop versus closed-loop thinking | EME 807: Technologies for Sustainability Systems* (no date). Available at: https://www.e-education.psu.edu/eme807/node/624 (Accessed: 11 June 2024); Morseletto, P. (2020) 'Targets for a circular economy', *Resources, Conservation and Recycling*, 153, p. 104553. Available at: https://doi.org/10.1016/j.resconrec.2019.104553; Team, G. (2023) *Growth of the Circular Economy and Development of Closed-Loop Supply Chains*, *Global Partner Solutions*. Available at: https://www.gpsi-intl.com/blog/growth-of-the-circular-economy-and-development-of-closed-loop-supply-chains/ (Accessed: 11 June 2024); Huysman, S. *et al.* (2015) 'The recyclability benefit rate of closed-loop and open-loop systems: A case study on plastic recycling in Flanders', *Resources, Conservation and Recycling*, 101. Available at: https://doi.org/10.1016/j.resconrec.2015.05.014.

[34] Ibid.; Mashudi *et al.* (2023) 'Innovative Strategies and Technologies in Waste Management in the Modern Era Integration of Sustainable Principles, Resource Efficiency, and Environmental Impact', *International Journal of Science and Society*, 5, pp. 87–100. Available at: https://doi.org/10.54783/ijsoc.v5i4.767.

[35] Simon, N. and Schulte, M.L., 2017. Stopping global plastic pollution: The case for an international convention. In *Stopping global plastic pollution: the case for an international convention: Simon, Nils| uSchulte, Maro Luisa*. Berlin: Heinrich-Böll-Stiftung, p.7.

[36] Manyara P, Raubenheimer K and Sadan Z, 'Legal and Policy Frameworks to Address Marine Litter Through Improved Livelihoods' in Thomas Maes and Fiona Preston-Whyte (eds), *The African Marine Litter Outlook* (Springer International Publishing 2023) <https://doi.org/10.1007/978-3-031-08626-7_4> accessed 11 June 2024; da Costa JP and others, 'The Role of Legislation, Regulatory Initiatives and Guidelines on the Control of Plastic Pollution' (2020) 8 Frontiers in Environmental Science <https://www.frontiersin.org/articles/10.3389/fenvs.2020.00104> accessed 11 June 2024.

The long-term durability of plastics in aquatic environments has the potential to cause marine pollution, which may have adverse effects on aquatic organisms.[37] The increasing accumulation of plastic garbage in the ocean is creating an urgent need for effective and environmentally-friendly solutions to address the issue.[38] Plastics have harmful effects on the ecosystem since they ruin habitats, entangle marine creatures, aid the spread of invasive species across habitats, and accumulate in sediments, potentially impacting the animals that reside and search for food on the ocean floor.[39]

Approximately 80% of the 59 million tonnes of rubbish generated ends up on shorelines, while a mere 12% is recycled. The residual plastic garbage contaminates the coastline.[40] Plastic debris in waterways has properties that make it attracted to water and have a high electrical charge compared to land.[41] Additionally, the presence of microbes may cause the plastics to break down into smaller pieces called microplastics. Bacterial growth and adherence to plastic debris may lead to the formation of microcolonies, which can have detrimental effects on aquatic life.[42] Scientists predict that by 2050, there will be a shortage of fish caused by the presence of plastics in the seas. Specifically, out of the 500 billion plastic bags, around 13 million tonnes of them wind up on the beach, resulting in the death of over 100,000 aquatic animals.[43] Plastics that are exposed to the ocean's surface

[37] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.
[38] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J. and Dunphy-Daly, M.M., 2020. Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, p.106067; Kosior, E. and Crescenzi, I., 2020. Solutions to the plastic waste problem on land and in the oceans. In *Plastic waste and recycling* (pp. 415-446). Academic Press.
[39] ibid
[40] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.
[41] Ibid.
[42] Ibid.
[43] Ibid.; Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637.

undergo weathering, which releases harmful greenhouse gases such as ethylene and methane.[44]

One possible solution is the development and deployment of devices designed to either prevent the entry of plastics into waterways or to gather and remove plastic pollution in marine and riverine environments.[45] These technologies have the potential to effectively support governmental initiatives in addressing the issue of marine plastic pollution.[46] The UNEA Resolution 2/11 proposes that member nations collaborate at both regional and international levels to address the issue of marine plastic hotspots.[47] It also calls for the development of ecologically sustainable systems and techniques to effectively remove and dispose of marine litter.[48] However, it is to noted that at the moment, there is a lack of efficient methods for the collection and remediation of plastic and microplastic pollution in the seas.[49] The primary effort needed to address plastic pollution and its related effects is prevention at the source.[50]

To avoid more plastic pollution and harm to aquatic ecosystems and human health, a comprehensive strategy that integrates technology, legislation, and activism is necessary.[51] As it, is the existing international regulations, governmental policies, non-

[44] Ibid.
[45] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J. and Dunphy-Daly, M.M., 2020. Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, p.106067.
[46] Ibid.
[47] Ibid.
[48] Ibid.
[49] Kosior, E. and Crescenzi, I., 2020. Solutions to the plastic waste problem on land and in the oceans. In *Plastic waste and recycling* (pp. 415-446). Academic Press.
[50] Ibid.
[51] Ibid.

state regulations, and consumer practices are insufficient in their strength and comprehensiveness to adequately safeguard the environment on a worldwide scale.[52]

2.2. Plastics and Public Health

Uncontrolled dumping of plastics on land and the act of burning them in the open may result in the emission of harmful chemicals into the atmosphere, which poses a risk to public health.[53] Plastic pollution has a direct influence on both human health and the environment, which in turn affects the environmental performance rating of any country.[54] Plastic additives, such as endocrine disruptors and carcinogens, have the potential to cause damage to people via skin contact, ingestion, and inhalation.[55] Microplastics are widespread environmental pollutants that people inevitably consume, leading to particle toxicity in all living organisms. This toxicity manifests as oxidative stress, inflammatory damage, and enhanced absorption or movement of artificial particles.[56] The immune system's failure to eliminate artificial particles may lead to

[52] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J. and Dunphy-Daly, M.M., 2020. Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, p.106067.

[53] Alabi, O.A., Ologbonjaye, K.I., Awosolu, O. and Alalade, O.E., 2019. Public and environmental health effects of plastic wastes disposal: a review. *J Toxicol Risk Assess*, *5*(021), pp.1-13.

[54] Pandey, P., Dhiman, M., Kansal, A. and Subudhi, S.P., 2023. Plastic waste management for sustainable environment: techniques and approaches. *Waste Disposal & Sustainable Energy*, *5*(2), pp.205-222.

[55] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

[56] Ibid.; Zhao, B. *et al.* (2024) 'The potential toxicity of microplastics on human health', *Science of The Total Environment*, 912, p. 168946. Available at: https://doi.org/10.1016/j.scitotenv.2023.168946; Emenike, E.C. *et al.* (2023) 'From oceans to dinner plates: The impact of microplastics on human health', *Heliyon*, 9(10), p. e20440. Available at: https://doi.org/10.1016/j.heliyon.2023.e20440; Bhuyan, M.S. (2022) 'Effects of Microplastics on Fish and in Human Health', *Frontiers in Environmental Science*, 10. Available at: https://doi.org/10.3389/fenvs.2022.827289; Ziani, K. *et al.* (2023) 'Microplastics: A Real Global Threat for Environment and Food Safety: A State of the Art Review', *Nutrients*, 15(3), p. 617. Available at: https://doi.org/10.3390/nu15030617.

persistent inflammation and heighten the likelihood of developing neoplasms.[57] Microplastics have the ability to release components, pollutants, and harmful organisms, which means they may be found everywhere in the environment and in consumer items.[58]

The non-toxic nature of plastic polymers, along with the existence of additives and leftover monomers, poses a huge danger to humanity. Plastic additives are substances that may alter the endocrine system and cause cancer.[59] They can affect people when they come into touch with the skin, are ingested, or are inhaled. Humans inevitably consume microplastics, which are widespread environmental pollutants, via eating, breathing, and skin contact.[60]

Exposure to microplastics may lead to particle toxicity in all living organisms, resulting in many harmful effects such as oxidative stress, inflammatory lesions, increased absorption or movement of particles, aberrant rearrangement of chromosomes, chronic inflammation, and heightened chance of developing carcinogenesis.[61] The primary route

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[57] Ibid.; Gonzalez, H., Hagerling, C. and Werb, Z. (2018) 'Roles of the immune system in cancer: from tumor initiation to metastatic progression', *Genes & Development*, 32(19–20), pp. 1267–1284. Available at: https://doi.org/10.1101/gad.314617.118.

[58] Ibid.; Lee, Y., Cho, J., Sohn, J. and Kim, C., 2023. Health effects of microplastic exposures: current issues and perspectives in South Korea. *Yonsei Medical Journal*, *64*(5), p.301.

[59] Ibid.; Ullah, Sana *et al.* (2022) 'A review of the endocrine disrupting effects of micro and nano plastic and their associated chemicals in mammals', *Frontiers in Endocrinology*, 13. Available at: https://doi.org/10.3389/fendo.2022.1084236; Bryce, E. (no date) *How Do Chemicals in Plastics Impact Your Endocrine System?*, *Scientific American*. Available at: https://www.scientificamerican.com/article/how-do-chemicals-in-plastics-impact-your-endocrine-system/ (Accessed: 11 June 2024); Maddela, N.R., Kakarla, D., Venkateswarlu, K. and Megharaj, M., 2023. Additives of plastics: Entry into the environment and potential risks to human and ecological health. *Journal of Environmental Management*, *348*, p.119364; Meeker, J.D., Sathyanarayana, S. and Swan, S.H. (2009) 'Phthalates and other additives in plastics: human exposure and associated health outcomes', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1526), pp. 2097–2113. Available at: https://doi.org/10.1098/rstb.2008.0268.

[60] Ibid.; Lin, Y.-D. *et al.* (2023) 'Sources, Degradation, Ingestion and Effects of Microplastics on Humans: A Review', *Toxics*, 11(9), p. 747. Available at: https://doi.org/10.3390/toxics11090747.

[61] Ibid.; Rahman, A., Yadav, O.P., Sarkar, A., Achari, G. and Slobodnik, J., 2020. Environmental exposure to microplastics: a scoping review on potential human health effects and knowledge gaps. *BLDE University Journal of Health Sciences*, *5*(Suppl 1), p. S25; Yee, M.S.-L. *et al.* (2021) 'Impact of Microplastics and

of human exposure is by ingestion, with an estimated intake of 39,000-52,000 particles per person per year. The interaction between the skin and microplastics is considered to be a less significant pathway of exposure.[62] Plastic additives and microplastics may be detrimental to people if consumed by animals.[63] Animals are very susceptible to encountering plastic debris on land or in bodies of water when they are eating, which may lead to fatalities in some instances.[64]

The effectiveness of organic phosphorus and nitrogen is diminished as a result of the disruption caused by plastic debris on the humus. Plastic debris present in soil obstructs the openings in plant root cell walls, resulting in a reduction in the uptake of nutrients and water.[65] Landfills are causing increasing worry among environmentalists and public health experts due to the presence of harmful substances and their ability to seep into the surrounding areas.[66]

It is thus evident from the foregoing that plastic pollution has penetrated every aspect of the environment and organisms' life. This creates a more urgent need to address the problem for sustainability.

Nanoplastics on Human Health', *Nanomaterials*, 11(2), p. 496. Available at: https://doi.org/10.3390/nano11020496.

[62] Ibid.; Yee, M.S.-L. *et al.* (2021) 'Impact of Microplastics and Nanoplastics on Human Health', *Nanomaterials*, 11(2), p. 496. Available at: https://doi.org/10.3390/nano11020496.

[63] Ibid.

[64] Ibid.; *What Happens When Animals Eat Plastic* (no date) *Plastic Soup Foundation*. Available at: https://www.plasticsoupfoundation.org/en/plastic-problem/plastic-affect-animals/animals-eat-plastic/ (Accessed: 11 June 2024); Zolotova, N. *et al.* (2022) 'Harmful effects of the microplastic pollution on animal health: a literature review', *PeerJ*, 10, p. e13503. Available at: https://doi.org/10.7717/peerj.13503; Lai, O. (2022) *The Detrimental Impacts of Plastic Pollution on Animals*, *Earth.Org*. Available at: https://earth.org/plastic-pollution-animals/ (Accessed: 11 June 2024); Ziani, K. *et al.* (2023) 'Microplastics: A Real Global Threat for Environment and Food Safety: A State of the Art Review', *Nutrients*, 15(3), p. 617. Available at: https://doi.org/10.3390/nu15030617.

[65] Ibid.

[66] Alabi, O.A., Ologbonjaye, K.I., Awosolu, O. and Alalade, O.E., 2019. Public and environmental health effects of plastic wastes disposal: a review. *J Toxicol Risk Assess*, *5*(021), pp.1-13.

3. International and Regional Approaches on Plastic Pollution Control

There is an increasing variety of suggestions on how to enhance international environmental legislation and policy in order to address the issue of plastic pollution, particularly in marine environments.[67] More than 80 nations have endorsed a Ministerial Statement advocating for an agreement that addresses plastic pollution across its entire life cycle and emphasizes the need to address the root causes of plastic pollution.[68]

The regulatory measures regarding plastic waste primarily target the reduction of plastic straws, plastic cutlery, and polystyrene items, including cups and microbeads. Nevertheless, the impact of multilateral accords and United Nations resolutions has been restricted up to this point.[69]

The United Nations (UN) Environment Assembly adopted a momentous resolution on March 2, 2022, with the objective of eradicating plastic pollution.[70] The resolution supported the creation of an intergovernmental negotiating committee (INC) to begin discussions with the goal of finalising a legally binding agreement by the end of 2024.[71]

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[67] Barrowclough, D. and Birkbeck, C.D. (2022) 'Transforming the Global Plastics Economy: The Role of Economic Policies in the Global Governance of Plastic Pollution', *Social Sciences*, 11(1), p. 26. Available at: https://doi.org/10.3390/socsci11010026.

[68] Ibid.

[69] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

[70] Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637.

[71] Ibid.; *Intergovernmental Negotiating Committee on Plastic Pollution* (no date) *UNEP - UN Environment Programme*. Available at: http://www.unep.org/inc-plastic-pollution (Accessed: 11 June 2024); 'Global Plastics Treaty | Intergovernmental Negotiating Committee' (no date) *Plastic Oceans International*. Available

The resolution seeks to tackle three primary goals: exploring various options to manage the whole life cycle of plastic waste, promoting the development of plastic materials and products that may be recycled and reused, and enhancing international cooperation to promote the adoption of innovative technologies.[72]

During the period from 2000 to 2019, a minimum of 28 global policies were implemented with the aim of decreasing plastic pollution.[73] Out of these, three policies are obligatory for member states: The Antarctic Treaty, London Convention and Protocol amendments, and the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V.[74] Regional governments have committed to gradually eliminating plastic microbeads by expressing their support and implementing regional action plans.[75] In the

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at: https://plasticoceans.org/global-plastics-treaty-intergovernmental-negotiating-committee/ (Accessed: 11 June 2024); see also *3rd Session of the Intergovernmental Negotiating Committee to Develop an International Legally Binding Instrument on Plastic Pollution, Including in the Marine Environment (INC-3)* (2022) *IISD Earth Negotiations Bulletin*. Available at: http://enb.iisd.org/plastic-pollution-marine-environment-negotiating-committee-inc3 (Accessed: 11 June 2024); *4th Session of the Intergovernmental Negotiating Committee to Develop an International Legally Binding Instrument on Plastic Pollution, Including in the Marine Environment (INC-4)* (2022) *IISD Earth Negotiations Bulletin*. Available at: http://enb.iisd.org/plastic-pollution-marine-environment-negotiating-committee-inc4 (Accessed: 11 June 2024).

[72] Ibid.; *Historic day in the campaign to beat plastic pollution: Nations commit to develop a legally binding agreement* (2022) *UN Environment*. Available at: http://www.unep.org/news-and-stories/press-release/historic-day-campaign-beat-plastic-pollution-nations-commit-develop (Accessed: 11 June 2024).

[73] Virdin, J., Karasik, R., Vegh, T., Pickle, A., Diana, Z., Rittschof, D., Bering, J. and Caldas, J., 2020. 20 Years of Government Responses to the Global Plastic Pollution Problem: The Plastics Policy Inventory.

[74] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J. and Dunphy-Daly, M.M., 2020. Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, p.106067.

[75] Ibid.; Usman, S. *et al.* (2022) 'The Burden of Microplastics Pollution and Contending Policies and Regulations', *International Journal of Environmental Research and Public Health*, 19(11), p. 6773. Available at: https://doi.org/10.3390/ijerph19116773; *Ban plastic microbeads in cosmetics | Department of Economic and Social Affairs* (no date). Available at: https://sdgs.un.org/partnerships/ban-plastic-microbeads-cosmetics (Accessed: 11 June 2024); *Economic consequences of unmanaged plastics and economic opportunities in the Western Indian Ocean: steps toward action plans - WIOMSA* (no date). Available at: https://www.wiomsa.org/publications/economic-consequences-of-unmanaged-plastics-and-economic-opportunities-in-the-western-indian-ocean-steps-toward-action-plans/ (Accessed: 11 June 2024).

last decade, both national and subnational governments have intensified their efforts to tackle the issue of plastic bags and single-use plastics.[76] These efforts have mostly included implementing bans, imposing levies, taxes, and fees, as well as encouraging volunteer initiatives.[77] Countries in sub-Saharan Africa, such Kenya, have implemented national policies that specifically address single-use plastic bags and other large plastic items, largely via the use of regulatory restrictions.[78]

Simultaneously, several other organisations carried out research and initiatives concerning marine litter and microplastics. These include the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention), the Strategic Approach to International Chemicals Management (SAICM), the International Maritime Organisation (IMO), the World Health Organisation (WHO),

[76] Ibid.; Knoblauch, D. and Mederake, L. (2021) 'Government policies combatting plastic pollution', *Current Opinion in Toxicology*, 28, pp. 87–96. Available at: https://doi.org/10.1016/j.cotox.2021.10.003; *Annual Trends in Plastics Policy: A Brief | The Nicholas Institute for Energy, Environment & Sustainability* (no date). Available at: https://nicholasinstitute.duke.edu/publications/annual-trends-plastics-policy-brief (Accessed: 11 June 2024); Molloy, S. *et al.* (2022) 'Public Perceptions of Legislative Action to Reduce Plastic Pollution: A Case Study of Atlantic Canada', *Sustainability*, 14(3), p. 1852. Available at: https://doi.org/10.3390/su14031852; *International Cooperation on Plastic Pollution | Plastics and the Environment Series* (no date). Available at: https://www.genevaenvironmentnetwork.org/resources/updates/international-cooperation-on-plastic-pollution/ (Accessed: 11 June 2024); *Kenya emerges as leader in fight against plastic pollution* (2021) *UNEP*. Available at: http://www.unep.org/news-and-stories/story/kenya-emerges-leader-fight-against-plastic-pollution (Accessed: 11 June 2024).

[77] Ibid.; Muposhi, A., Mpinganjira, M. and Wait, M. (2022) 'Considerations, benefits and unintended consequences of banning plastic shopping bags for environmental sustainability: A systematic literature review', *Waste Management & Research*, 40(3), pp. 248–261. Available at: https://doi.org/10.1177/0734242X211003965.

[78] Ibid.; *Kenya bans single-use plastics in protected areas* (no date). Available at: https://www.unep.org/news-and-stories/story/kenya-bans-single-use-plastics-protected-areas (Accessed: 11 June 2024).

the World Trade Organisation (WTO), and various Regional Seas Programmes and Conventions.[79]

4. Towards Healthy Ecosystems: Addressing Plastic for Sustainability

Tackling the issue of plastics requires a comprehensive approach that encompasses legal, economic, and technical measures.[80] The proliferation of plastic pollution is projected to persist and grow in the next decades, despite the unsuccessful attempts of governments, civic society, and companies to mitigate its impact.[81] In order to address the issue of plastic pollution, it is necessary to develop sustainable markets by implementing a wide range of policy tools.[82] These tools should include incentives for both producers and consumers, as well as steps to improve solid waste management systems.[83] However, it is important to note that transitioning to a comprehensive strategy takes careful planning and a step-by-step process.[84]

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[79] *Summary report 23–29 April 2024* (no date) *IISD Earth Negotiations Bulletin*. Available at: http://enb.iisd.org/plastic-pollution-marine-environment-negotiating-committee-inc4-summary (Accessed: 11 June 2024); see also *4th Session of the Intergovernmental Negotiating Committee to Develop an International Legally Binding Instrument on Plastic Pollution, Including in the Marine Environment (INC-4)* (2022) *IISD Earth Negotiations Bulletin*. Available at: http://enb.iisd.org/plastic-pollution-marine-environment-negotiating-committee-inc4 (Accessed: 11 June 2024).

[80] *Environmental conservation from plastic pollution* (2023) *A Light Bulb of Youth In African Development*. Available at: https://www.theyouthcafe.com/perspectives/environmental-conservation-from-plastic-pollution (Accessed: 8 June 2024);

[81] Barrowclough, D. and Birkbeck, C.D. (2022) 'Transforming the Global Plastics Economy: The Role of Economic Policies in the Global Governance of Plastic Pollution', *Social Sciences*, 11(1), p. 26. Available at: https://doi.org/10.3390/socsci11010026.

[82] *Pathways out of Plastic Pollution* (no date) *World Bank*. Available at: https://www.worldbank.org/en/topic/environment/publication/pathways-out-of-plastic-pollution (Accessed: 8 June 2024).

[83] ibid

[84] Ibid.

The prevailing and traditional approach to managing plastic garbage in many countries involves the methods of landfilling and incineration.[85] Incinerating plastic garbage is ecologically detrimental because to its contribution to global warming and the potential for leaching into the environment.[86] Disposing of plastic garbage in landfills is undesirable because plastic is non-biodegradable and has the potential to release harmful substances into the environment.[87] In addition, the presence of plastic garbage in gutters creates ideal conditions for mosquitoes to flourish, leading to the transmission of diseases including malaria, dysentery, and epidemic cholera to the general population.[88]

4.1. Development of Tailored Country Specific Strategies and National Action Plans

Given the rising worry over the detrimental effects of plastics on the environment and human well-being, several governments are taking more action to address this issue at the local, national, and international scales.[89] The implementation of local laws aimed at reducing plastic pollution has had a global impact, leading to increasing efforts globally.[90] As part of the upcoming international agreement aimed at stopping plastic pollution, governments will probably be required to create action plans and policies to effectively handle plastic pollution.[91] These plans should integrate conventional methods of

[85] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.
[86] Ibid.
[87] Ibid.
[88] Ibid.
[89] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J. and Dunphy-Daly, M.M., 2020. Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, p.106067.
[90] Ibid.
[91] *Pathways out of Plastic Pollution* (no date) *World Bank*. Available at: https://www.worldbank.org/en/topic/environment/publication/pathways-out-of-plastic-pollution (Accessed: 8 June 2024).

managing solid waste with strategies focused on pollution reduction, such as industry and product regulations.[92] It is necessary to guarantee that the plastics policy sets specific goals and accurately models the financial, social, fiscal, climatic, and employment effects of different policies on companies, people, and the government in order to prevent future difficulties in carrying out the policy.[93]

4.2.Role of Technology

While governments do play a significant role in addressing marine trash, private business activity and technology innovation are more impactful in combatting this issue.[94] Both for-profit organisations and non-governmental organisations (NGOs) are actively working on creating new technologies aimed at mitigating the adverse effects of plastic pollution.[95] These technologies target various phases of the plastic life cycle, such as manufacture, use, and waste management, which may include landfilling, recycling, or repurposing.[96] Developing cutting-edge recycling technologies is crucial for identifying new recycled materials that possess beneficial characteristics, which may enhance industrial processes and aid all nations in achieving worldwide sustainability objectives.[97] The progress of technology is crucial for the mitigation of plastic pollution, and funding for research and development is not inherently a political strategy but rather

[92] Ibid.
[93] Ibid.
[94] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J. and Dunphy-Daly, M.M., 2020. Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, p.106067.
[95] Ibid.
[96] Ibid.
[97] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

an outcome of a well-crafted combination of policies.[98] Remediation techniques for plastic waste include the conversion of garbage into power, energy, and value-added goods, such as chemicals.[99] The circular economy concept promotes the efficient utilisation of resources by implementing practices such as recycling, reusing, repairing, remanufacturing, and refurbishing things.[100] Effective collaboration among all parties involved is essential for the progress of plastic waste management in the circular economy.[101]

Technologies designed to tackle these problems focus on either 1) directly limiting the flow of plastic into rivers or 2) gathering and removing plastic pollution that already exists. Exploration of new recycling options, such as plastic-to-fuel and bioremediation, is taking place throughout the recycling process.[102]

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[98] Ibid.; Tanuja, G. *et al.* (2023) 'Innovative Technologies for Sustainable Recycling and Re-manufacturing of Materials and Components', *E3S Web of Conferences*, 430. Available at: https://doi.org/10.1051/e3sconf/202343001130.

[99] Ibid.; Vuppaladadiyam, S.S.V. *et al.* (2024) 'Waste to energy: Trending key challenges and current technologies in waste plastic management', *Science of The Total Environment*, 913, p. 169436. Available at: https://doi.org/10.1016/j.scitotenv.2023.169436.

[100] Ibid.; *Circular economy introduction* (no date). Available at: https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview (Accessed: 11 June 2024).

[101] Ibid.; *3 ways we can collaborate better for a circular economy* (2022) *World Economic Forum*. Available at: https://www.weforum.org/agenda/2022/05/3-ways-we-can-collaborate-better-for-a-circular-economy/ (Accessed: 11 June 2024); Prabawati, A., Frimawaty, E. and Haryanto, J. (2023) 'Strengthening Stakeholder Partnership in Plastics Waste Management Based on Circular Economy Paradigm', *Sustainability*, 15, p. 4278. Available at: https://doi.org/10.3390/su15054278; *Steering the Course to a Zero Waste and Circular Economy* (no date) *UNDP*. Available at: https://www.undp.org/ghana/blog/steering-course-zero-waste-and-circular-economy (Accessed: 11 June 2024).

[102] Schmaltz, E., Melvin, E.C., Diana, Z., Gunady, E.F., Rittschof, D., Somarelli, J.A., Virdin, J. and Dunphy-Daly, M.M., 2020. Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. *Environment international*, *144*, p.106067.

4.3. Enhanced Public Awareness on Plastic Reuse, Waste Reduction and Recycling

The rising use of plastic goods has resulted in substantial plastic trash. It is essential to have a clear understanding of how they are used and to effectively manage their regular activities.[103] Plastics are being utilised more and more in many industries, such as food packaging, brewing, cosmetics, pharmaceuticals, and other manufacturing sectors, to ensure efficient and safe delivery.[104]

It is essential to enhance public awareness about trash segregation and appropriate waste disposal protocols in order to reduce plastic use.[105] Waste reduction entails the creation and manufacturing of items that have a small size and contain low levels of toxins, hence promoting a longer lifespan for the product, utilisation of plastic waste for many objectives, including the construction of bricks, the reduction of trash generation, the mitigation of water deterioration and pollution, the minimization of dumping area, and the provision of a unique technique for using plastic waste.[106] Reutilization, recycling, and conversion of energy are techniques used to mitigate environmental contamination resulting from plastic trash.[107]

The utilisation of plastic waste offers several advantages, such as minimising the consumption of natural resources in brick production, decreasing plastic waste

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[103] Evode, N., Qamar, S.A., Bilal, M., Barceló, D. and Iqbal, H.M., 2021. Plastic waste and its management strategies for environmental sustainability. *Case Studies in Chemical and Environmental Engineering*, *4*, p.100142.

[104] Ibid.; Alabi, O.A., Ologbonjaye, K.I., Awosolu, O. and Alalade, O.E., 2019. Public and environmental health effects of plastic wastes disposal: a review. *J Toxicol Risk Assess*, *5*(021), pp.1-13.

[105] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

[106] Ibid.; Vuppaladadiyam, S.S.V. *et al.* (2024) 'Waste to energy: Trending key challenges and current technologies in waste plastic management', *Science of The Total Environment*, 913, p. 169436. Available at: https://doi.org/10.1016/j.scitotenv.2023.169436.

[107] Ibid.

generation, mitigating water degradation and pollution, reducing the required space for waste disposal, expanding agricultural land, and providing an innovative method for utilising plastic waste.[108]

4.4. Efficient Waste Management

Industrial development yields an abundance of products for human endeavours, but it also produces substantial amounts of environmental waste, including gases, water, and solid materials.[109] Plastic waste, a substantial commodity, has a key role in exacerbating these problems, underscoring the need for implementing sustainable measures in the sector.[110]

Efficient waste management and remediation techniques are crucial for improving technology that facilitate the recycling or energy extraction of plastics already present in landfills.[111] The waste-to-energy initiative focuses on implementing methods to reduce the accumulation of plastic in landfills and conducts campaigns to promote a shift in consumer behaviour, urging individuals to refrain from using throwaway products such as single-use plastics.[112]

[108] Ibid.
[109] Zhang, F., Zhao, Y., Wang, D., Yan, M., Zhang, J., Zhang, P., Ding, T., Chen, L. and Chen, C., 2021. Current technologies for plastic waste treatment: A review. *Journal of Cleaner Production*, *282*, p.124523.
[110] Ibid.
[111] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.
[112] Ibid.

Enhancing the proper disposal and prevention of plastic leakage after its usefulness has ended may have significant impacts on human beings, the environment, and the ecosystem.[113]

4.5. Role of Economic Policies

Extended Producer Responsibility (EPR) is a fundamental approach based on rights that aims to encourage waste reduction, reduce the use of new materials, and promote the growth of the recycling sector.[114] Imposing a charge on single-use plastics, together with promoting shifts in consumer preferences and implementing awareness programmes, might encourage investment in finding suitable alternative alternatives.[115] Efficient incentives should be put in place to minimise the transportation of garbage to landfills.[116] The government should promote the adoption of circular economy ideas by enterprises in the plastics industry. These principles emphasise the efficient utilisation of resources via practices such as recycling, reusing, repairing, remanufacturing, and refurbishing items.[117]

5. Conclusion

[113] Pandey, P., Dhiman, M., Kansal, A. and Subudhi, S.P., 2023. Plastic waste management for sustainable environment: techniques and approaches. *Waste Disposal & Sustainable Energy*, *5*(2), pp.205-222.
[114] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.
[115] Ibid.
[116] Ibid.
[117] Ibid.; *Understanding the Circular Economy: Principles, Benefits, and Applications | Heinrich-Böll-Stiftung | Tel Aviv - Israel* (no date). Available at: https://il.boell.org/en/2024/03/09/understanding-circular-economy-principles-benefits-and-applications (Accessed: 11 June 2024).

Plastic pollution is a worldwide problem that impacts both land-based and water-based ecosystems.[118] The source of this issue may be attributed to irresponsible consumption, insufficient recycling practices, and the accumulation of waste in landfills.[119] There is a significant and accelerating rise in the release of plastic garbage into ecosystems.[120] Researchers, politicians, and stakeholders have a significant problem in managing plastic trash.[121] Mitigation measures include the implementation of regulations to prohibit plastic, raising public awareness, conducting life cycle assessments, promoting circularity, and fostering innovation to minimise the use of plastics via reduction, reuse, recycling, and recovery.[122] Facilitating the ability of communities and people to collectively engage in action is of paramount significance. The problem of plastic pollution is a global issue that needs a collective effort to be overcome.[123] Enhancing

[118] Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P.K., Kumar, R., Kumar, P., Shubham, Das, S. and Sharma, P., 2021. Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability*, *13*(17), p.9963.

[119] Ibid.

[120] Ibid.

[121] Ibid.; Nielsen, T.D. *et al.* (2020) 'Politics and the plastic crisis: A review throughout the plastic life cycle', *WIREs Energy and Environment*, 9(1), p. e360. Available at: https://doi.org/10.1002/wene.360; Bharadwaj, B. and Rai, R. (2021) 'Stakeholders Perception of Used Plastics', in. Available at: https://doi.org/10.1007/978-981-15-7525-9_54-1; Joseph, K. (2006) 'Stakeholder participation for sustainable waste management', *Habitat International*, 30(4), pp. 863–871. Available at: https://doi.org/10.1016/j.habitatint.2005.09.009; McNicholas, G. and Cotton, M. (2019) 'Stakeholder perceptions of marine plastic waste management in the United Kingdom', *Ecological Economics*, 163, pp. 77–87. Available at: https://doi.org/10.1016/j.ecolecon.2019.04.022; Vandenberg, J. (2024) 'Plastic Politics of Delay: How Political Corporate Social Responsibility Discourses Produce and Reinforce Inequality in Plastic Waste Governance', *Global Environmental Politics*, 24(2), pp. 122–145. Available at: https://doi.org/10.1162/glep_a_00745.

[122] Ibid.

[123] Ibid.; *Collective action against plastic pollution: A global priority agenda* (no date) *orfonline.org*. Available at: https://www.orfonline.org/expert-speak/collective-action-against-plastic-pollution (Accessed: 11 June 2024); *How empowering local communities can help solve global plastic waste* (2022) *World Economic Forum*. Available at: https://www.weforum.org/agenda/2022/01/empowering-local-communities-help-solve-global-plastic-waste/ (Accessed: 11 June 2024); Kumar, Rakesh *et al.* (2021) 'Impacts of Plastic Pollution on Ecosystem Services, Sustainable Development Goals, and Need to Focus on Circular Economy and Policy Interventions', *Sustainability*, 13(17), p. 9963. Available at: https://doi.org/10.3390/su13179963; *How empowering local communities can help solve global plastic waste* (2022) *World Economic Forum*. Available at:

confidence in studies on plastic waste management should foster better cooperation among key stakeholders, including central governments, local governments, research institutions, NGOs, plastic producers, buyers, and waste dispersers or separators.[124]

Plastic trash is a major contributor to the problem of white pollution and presents substantial health hazards to people, animals, and the environment.[125] The projected doubling of plastic imports over the next five years will have a substantial effect on human health, animal health, and the environment.[126] Ultimately, the use of reusing, recycling, and energy conversion proves to be an efficacious approach in mitigating the environmental contamination stemming from plastic waste.[127]

There are several traditional and emergent approaches to effectively handle plastic garbage. Landfilling is a traditional method used for the management of plastic trash, while incineration is a contemporary and very efficient approach.[128] These methods have their benefits and drawbacks, but they need to be thoroughly evaluated and executed in order to efficiently control and diminish plastic trash. [129]

Additional investigation is required to transform plastic trash into raw materials for the production of high-value goods in order to accomplish a circular economy.[130]

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https://www.weforum.org/agenda/2022/01/empowering-local-communities-help-solve-global-plastic-waste/ (Accessed: 11 June 2024).

[124] Ibid.; *A vision for sustainable waste management in Nairobi* (no date). Available at: https://www.climate-kic.org/news/a-vision-for-sustainable-waste-management-in-nairobi/ (Accessed: 11 June 2024).

[125] Ibid.

[126] Ibid.

[127] Ibid.

[128] Maitlo, G., Ali, I., Maitlo, H.A., Ali, S., Unar, I.N., Ahmad, M.B., Bhutto, D.K., Karmani, R.K., Naich, S.U.R., Sajjad, R.U. and Ali, S., 2022. Plastic waste recycling, applications, and future prospects for a sustainable environment. *Sustainability*, *14*(18), p.11637.

[129] Ibid.

[130] Khoaele, K.K., Gbadeyan, O.J., Chunilall, V. and Sithole, B., 2023. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability 2023, 15, 5233.

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'Kenya Plastic Bag Ban Notice No. 2356 - The Environmental Management and Co-ordination Act (Plastic Bag Ban on Secondary Packaging)' (no date) *Global Plastics Policy Centre*. Available at: https://plasticspolicy.port.ac.uk/policy-reviews/kenya-plastic-bag-ban/ (Accessed: 11 June 2024).

3 ways we can collaborate better for a circular economy (2022) *World Economic Forum*. Available at: https://www.weforum.org/agenda/2022/05/3-ways-we-can-collaborate-better-for-a-circular-economy/ (Accessed: 11 June 2024).

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4th Session of the Intergovernmental Negotiating Committee to Develop an International Legally Binding Instrument on Plastic Pollution, Including in the Marine Environment (INC-4) (2022) *IISD Earth Negotiations Bulletin*. Available at: http://enb.iisd.org/plastic-pollution-marine-environment-negotiating-committee-inc4 (Accessed: 11 June 2024).

5.2. Recycling: open-loop versus closed-loop thinking | EME 807: Technologies for Sustainability Systems (no date). Available at: https://www.e-education.psu.edu/eme807/node/624 (Accessed: 11 June 2024).

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