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Original Research

The Effect of Waste Plastic on Environmental Degradation: A Corporate Perspective

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Abstract

We are living in an era where environmental challenges are at their peak, and one of the reasons for such challenges is the use of plastic. Therefore, the key objective of the current study is to test the effect of waste plastic on environmental degradation. This study is empirical in nature, and we use data from the World Bank (World Development Indicators) to testify to the said nexus. This study is conducted particularly in the context of eight (8) Asian countries across ten (10) years. By using multivariate regression models, the statistical results testify that the use of waste plastic leads to environmental degradation. These outcomes are further robustly checked by using multiple proxies for both waste plastic usage and environmental degradation. These results indicate that the use of waste plastics has harmful impacts that are becoming obvious and greatly contribute to environmental deterioration. Moreover, the higher recycling rate helps minimize the consequences of waste plastic. This study significantly contributes to environmental policies and the safety level, particularly with respect to the use of waste plastic.

Keywords: waste plastic, environmental degradation, pollution, recycling, Asian countries

Introduction

Plastic remains an effective material; therefore, even considering its adverse impact on human health and the environment, many countries are still widely using it, particularly Asian countries [1]. Although studies on the effects of plastic trash and its monitoring are still in their infancy, the results are unsettling [2]. Therefore, this study will look at the environmental impact of waste plastic and the challenges associated with managing plastic waste.

Despite its benefits, the production and disposal of plastic have severe environmental consequences [3, 4]. Most plastic trash is thrown away in landfills or in the ocean, damaging ecosystems and wildlife [5, 6]. Marine species (e.g., sea turtles, whales, and others) commonly

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get tangled in plastic trash or mistake it for food, which can cause harm or death to them [7, 8]. Furthermore, the disposal of plastic releases toxic chemicals such as lead, phthalates, and cadmium that can scum into soil and groundwater, subsequently contaminating them [9].

Waste plastic has become one of the most significant environmental issues in recent times [10]. Plastic is frequently used and does not spoil; thus, it lasts longer in the environment after being thrown away. The buildup of waste plastic in the environment has an effect on nature as well as on the soil quality, the air quality, and the water quality [11]. This study makes an effort to evaluate the consequences of waste plastic on the environment and highlight how serious the problem is. The United Nations program for environment claims that "single-use plastics, such as plastic bottles, caps, cigarette butts, supermarket bags, lids, stirrers, straws, and food wrappers, are an indication of insufficient waste management systems and our attitude towards natural ecosystems [12]".

The chemicals associated with waste plastic (e.g., dioxins, lead, cadmium, phthalates, etc.) have harmful effects for both humans and wildlife [13]. In addition to worries about the effects of various chemicals and the reliance on limited resources for the production of plastic, current patterns of usage also contribute to global waste management difficulties [14]. Plastic remains are causing a wide range of problems, and monitoring their rate of change is crucial [15]. Therefore, this study could significantly contribute to the field of environmental economics and policymaking regarding the use and management of waste plastic. Asian countries are among those countries that are producing, consuming, and disposing of plastic, thus facing multiple environmental challenges.

By considering environmental concerns and managing waste plastic, cumulative efforts are required by individuals, organizations, and governments [16]. It is time to take actions regarding the protection of the environment and the prevention of waste plastic and save our future generations from the harmful effects of waste plastic and environmental degradation. The findings of this study provide valuable insights into the impact of waste plastic and help in making decisions regarding public awareness to address the said issues. By studying the impacts of plastic waste, authorities can work towards minimizing our plastic consumption, promoting recycling and reuse, and preventing further harm to the environment.

The motivation behind conducting research on waste plastic and environmental degradation comes from an urgent need to address the concerns raised by pollution and ecological issues that eventually affect society and human health. As plastic waste is increasing at an alarming rate, particularly in landfills and oceans, it is needed to understand its subsequent impact on environmental challenges. Understanding the said nexus is also important for devising effective strategies and policy implications. Therefore, the main purpose of this study is to explore the said nexus. Moreover, awareness among potential stakeholders, innovative solutions to mitigate environmental challenges, and mutual global collaborations are required to manage plastic waste and its environmental consequences.

The structure of this study is as follows: Section 2 debates the philosophy of the study. In Section 3, methodology, variable measurement, and empirical models are presented. Section 4 documents the empirical analysis and discussion. Lastly, the conclusion, policy implications, limitations, and future research directions are discussed in Section 5 of this paper.

The Philosophy of the Study

Millions of plastic products are bought and sold every minute worldwide [17], and this number is predicted to rise even more in the coming years, causing an environmental problem that could have an impact on global climate change [18]. Due to their inability to control plastic pollution, natural eco-systems are at risk due to plastic waste, and they also adversely influence eco-system facilities and lifestyles, particularly within the shoreline of developing economies [19]. People living in the said countries are more vulnerable to natural disasters and climatic phenomena. Therefore, activities to demand robust surroundings with less plastic exposure and pollution are necessary for the development of the economy, society, and environment [20].

Some recent literature has highlighted the role of waste plastic in environmental degradation. For example, Redko et al. [21] evaluated the environmental and health concerns associated with disposing of waste plastic in municipal waste landfills (MWL). The findings suggested that disposing of waste plastic using the MWL approach contributes to severe environmental pollution and risks to human health. Similarly, by using the life cycle cost analysis (LCCA) approach, Hao, et al. [22] investigated the economic and environmental implications of recycling waste plastic. The results testified that recycling waste plastic can contribute positively to reducing environmental pollution. Additionally, more effective use of waste plastic can result in economic benefits. Moreover, in a study to evaluate biodegradation, Aguiar, et al. [23] analyzed the consequences of waste plastic. The findings propose that managing waste plastic has a significant effect on the environment and biodegradation.

In an evaluation of waste management systems, Afshar, et al. [24] examined the impact of waste plastic on the open environment. The findings support the narrative that an efficient waste management system is not only vital for reducing biodegradation but also for an open environment as well. Furthermore, in a study on India, Chowdhury, et al. [25] reviewed the trends regarding managing waste plastic and its subsequent impact on the sustainable environment. The assessment

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has also discussed the governmental policies on managing plastic waste, their subsequent challenges, and their future scope. Pandey, et al. [26] also investigated the role of plastic and its waste in creating pollution and environmental concerns. The review provided policymakers with knowledge to develop efficient techniques and approaches to minimize the global challenges raised by plastic pollution and its subsequent ecological concerns.

In a critical review by Tiwari, et al. [27] on the future perspective of recycling waste plastic and its favorable impact on ecology, Using multiple indicators for recycling waste plastic, the authors proposed the bright side of recycling for the environment. Correspondingly, in a study to explore the environmental consequences of waste plastics, Idris, et al. [28] proposed the use of biodegradable polymers as an alternative to plastic. The said biodegradable materials have the capacity to replace conventional plastics and have a favorable impact on the environment.

The detrimental effects of pollution caused by waste plastic and opportunities to generate income could lead to new challenges [29]. For enhancing or developing livelihoods, there must be international trade between rich and poor nations for plastic trash as well as a market for informal waste treatment [30, 31]. Our capacity for disposing of waste in landfills is limited, and in some locations, landfills are at or are rapidly approaching capacity. This phenomenon has been highlighted by Barnes, et al. [32]. The disposal of plastic waste in open lands and oceans could have negative ecological effects. Plastic waste can contaminate the environment for hundreds of years and emit microplastics and hazardous compounds that can be harmful to ecosystems and wildlife.

The recent decade has witnessed an intensive increase in the production of plastic [33, 34]. This extensive production of plastic has ultimately resulted in higher waste [35]. Unfortunately, only a very limited amount of waste plastic is further recycled, and the majority of nonrecycled waste plastic is disposed of in an inappropriate manner, thus raising multiple environmental concerns [36, 37]. Such an inappropriate disposal took hundreds of years to decompose. The said assumptions are clarified in the studies of Jambeck, et al. [38].

There is a direct relationship between the production of plastic and its waste, i.e., as the production of plastic increases, the waste plastic is also resultantly increased [39]. Such phenomena were empirically tested by Geyer, et al. [40]. Furthermore, waste plastic production is influenced by the plastic recycling rate, including the accessibility and efficiency of recycling infrastructure [41, 42]. Much of the plastic trash produced in countries with insufficient recycling facilities ends up in landfills and burners [43]. Such an inappropriate ending subsequently has negative consequences for the environment. Borrelle, et al. [44] found similar findings in their study on waste plastic and pollution.

Another important aspect that has an impact on the environment via waste plastic is the consumption of plastic [45, 46]. Straws, plastic bags, and water bottles are just a few examples of single-use plastic that greatly increase the amount of plastic trash and subsequently harm the environment [3]. Jambeck, et al. [38] observed the same concern in 192 coastal countries and found that the majority of waste plastic on coasts came from single-use plastics.

Plastic is a significant hazardous contaminant in the current era. It is comprised of toxic chemicals and is particularly concerning due to its non-biodegradable features, leading to pollution of the earth, air, and water [13, 47]. This pollution affects the environment, humans, and animals through the food chain. Plastic garbage cannot be disposed of safely, and the production, use, and disposal processes all have a negative impact on the environment [48]. Waring, et al. [49] examined similar challenges in the cases of public health and the environment.

Waste plastic also has detrimental environmental effects at the expense of dangerous synthetic compounds during its production [4, 50]. These chemicals, which are frequently used in or left over from the manufacture of plastic, comprise a variety of neurotoxic, carcinogenic, and hormone-disrupting substances [51]. They unavoidably pollute our ecosystem through the land, water, and air. The same viewpoint was adopted by Evode, et al. [4] in their study on waste management strategies for environmental sustainability.

Mismanagement of plastic trash has an impact on land ecosystems [52]. It is also important to understand how waste is managed and disposed of. Inappropriate disposal of waste plastic, such as burning and dumping, subsequently creates drastic implications, e.g., carbon dioxide emissions, environmental degradation, and climate change [53, 54]. One of the recent studies by Kumar, et al. [52] also testified to the said narrative in the context of the circular economy model. By following the supportive literature and aforementioned discussion, we can hypothesize that:

Hypothesis: Waste plastic has an adverse environmental influence.

Methodology

Sample and Data Sources

To analyze the impact of waste plastic on environmental degradation, we have selected a sample of eight (8) Asian countries, i.e., Bangladesh, India, Indonesia, Iran, Japan, Malaysia, Pakistan, and the Philippines. There are multiple reasons for choosing Asia as a sample. Firstly, Asian countries have witnessed enormous economic growth in the past decade [55]. Such economic growth comes from industrialization and massive production, which eventually enhance plastic production and consumption [56]. Higher production

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and consumption of plastic lead to intensive waste. Secondly, most Asian countries have a very limited infrastructure regarding waste management and recycling; therefore, these countries faced extreme environmental challenges caused by mismanaged and nonrecycled waste plastic [57].

We collect empirical data from World Development Indicators (WDI) developed by the World Bank during the period from 2011 to 2020. The WDI database has a rich source of numerical data on a range of topics such as economy, culture, education, environment, pollution, etc. Policymakers, practitioners, and researchers from various domains used WDI datasets for their respective purposes [58]. This database is updated on a regular basis and accessed openly and freely using the World Bank's data catalog.

Variables Measurement

The dependent variable of this study is environmental degradation. Previous studies used multiple proxies to quantify environmental degradation, e.g., Bartram and Ballance [59] used water pollution, Pauly, et al. [60] identified overfishing, Pimm, et al. [61] highlighted habitat destruction, Tilman, et al. [62] classified biodiversity loss, Bai, et al. [63] emphasized soil degradation, and Lelieveld, et al. [64] identified air pollution. However, contrary to the said studies, we use two proxies for environmental degradation. The first proxy is climate change, measured by the emission of greenhouse gases (GHGs), including carbon emissions. The second proxy is deforestation, measured as the loss of forested land.

We use waste plastic as an independent variable in this study. The recent literature has witnessed multiple ways to estimate waste plastic, i.e., Kawecki and Nowack [65] used plastic production and consumption, and Lieto, et al. [66] identified total organic carbon. But we incorporate two diverse indicators for waste plastic, i.e., plastic waste pollution level and plastic waste recycling rates.

In this study, two various types of control variables are used, i.e., industrialization and urbanization. Both of these indicators have an impact on environmental degradation. Traditional industrial setups require a high amount of petrochemicals, which eventually leads to higher environmental challenges. Similarly, the development of urban populations increases the demand for transportation and production, which consequently creates environmental concerns.

Estimation Techniques and Empirical Modeling

Based on the nature of the dataset and the construction of variables, we incorporate regression estimation techniques to explore the nexus between waste plastic and environmental degradation. Moreover, we developed the below-mentioned empirical model, which explains the relationship between dependent, independent, and control variables at time t and country k.

$$Environmental\ Degradation_{tk} = \beta_0 + \beta_1 Waste\ Plastic_{tk} + \sum_{i=1}^{02} \beta_j\ Controls_{tk} + e_{tk} \tag{1}$$

$$Climate\ Change_{tk} = \beta_0 + \beta_1 Waste\ Plastic\ (Pollution)_{tk} + \sum_{i=1}^{2} \beta_j\ Controls_{tk} + e_{tk} \tag{1.1}$$

02

$$Climate\ Change_{tk} = \beta_0 + \beta_1 Waste\ Plastic\ (Recycling)_{tk} + \sum_{i=1} \beta_j\ Controls_{tk} + e_{tk} \tag{1.2}$$

$$Deforestation_{tk} = \beta_0 + \beta_1 Waste\ Plastic\ (Pollution)_{tk} + \sum_{i=1}^{02} \beta_j\ Controls_{tk} + e_{tk} \tag{1.3}$$

$$Deforestation_{tk} = \beta_0 + \beta_1 Waste\ Plastic\ (Recycling)_{tk} + \sum_{i=1}^{02} \beta_j\ Controls_{tk} + e_{tk} \tag{1.4}$$

Empirical Analysis

We empirically investigate the impact of waste plastic on environmental degradation by using macro-level indicators. The descriptive statistics of the data utilized to demonstrate the aforementioned link are shown in Table 1. The total number of observations, their mean value, standard deviation, and lowest and maximum values are all included in the table of descriptive statistics.

As a diagnostic tool, we use correlation analysis to dig into the data to find any probability of a collinearity issue. According to the values given in Table 2, our statistical data is free from collinearity concerns.

We use regression estimates to quantify the impact of waste plastic on environmental degradation. Table 3 presents the results by using climate change as a proxy for environmental degradation, plastic waste pollution level, and recycling rates as proxies for waste plastic. As per reported findings, the pollution level of waste plastic has a negative impact on climate change. Moreover, the recycling rate of waste plastic has positive consequences for climate change. These results support our hypothesis and align with the previous literature, i.e., pollution caused by waste plastic enhances carbon emissions

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Table 1. Descriptive Analysis.

Variables	Obs.	Mean	Std. Dev.	Min	Max
Climate change	80	32.64	22.97	4.09	72.88
Deforestation	80	30.93	22.68	4.83	68.48
Plastic waste pollution level	80	2.43	2.29	0.17	8.23
Plastic waste recycling rates	80	15.40	12.83	0.21	35.02
Industrialization	80	84.36	17.24	48.09	100
Urbanization	80	37.24	26.18	13.05	100

Table 2. Correlation Matrix.

	A	B	C	D	E	F
A	1.0000					
B	-0.4892	1.0000				
C	0.1765	0.4834	1.0000			
D	0.1128	-0.4756	0.1516	1.0000		
E	-0.0343	-0.2084	0.5524	-0.0594	1.0000	
F	-0.3269	0.6235	0.7156	-0.2084	-0.7125	1.0000

A = Climate Change, B = Deforestation, C = Plastic Waste Pollution Level, D = Plastic Waste Recycling Rates, E = Industrialization, F = Urbanization

Table 3. Regressions.

Regression Estimates			
Unit of Observation – Panel			
Dependent Variable – Climate Change			
Independent Variables		Model – 1.1	Model – 1.2
Waste Plastic (Pollution Level)	*Coefficient*	7.9923	
	T – Stats	(7.33)***	
Waste Plastic (Recycling Rate)	Coefficient		-0.1404
	T – Stats		(-2.74)**
Control Variables			
Industrialization	*Coefficient*	0.6311	0.7631
	T – Stats	(4.36)***	(3.89)***
Urbanization	*Coefficient*	1.0851	0.6611
	T – Stats	(9.54)***	(4.99)***
Model Summery			
Number of Observations		80	80
F – Stats		32.46	8.77
Prob. > F – Stats		0.0000	0.0000
R – Square		0.5617	0.2572
Adjusted R – Square		0.5444	0.2279

*p<0.1, **p<0.05, ***p<0.01

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Table 4. Regressions.

Regression Estimates			
Unit of Observation – Panel			
Dependent Variable – Deforestation			
Independent Variables		Model – 1.3	Model – 1.4
Waste Plastic (Pollution Level)	*Coefficient*	1.1725	
	T – Stats	(2.03)**	
Waste Plastic (Recycling Rate)	Coefficient		-0.5006
	T – Stats		(-3.51)***
Control Variables			
Industrialization	*Coefficient*	0.6438	0.4730
	T – Stats	(4.25)***	(3.20)**
Urbanization	*Coefficient*	0.7684	0.7109
	T – Stats	(6.46)***	(7.16)***
Model Summery			
Number of Observations		80	80
F – Stats		26.22	33.78
Prob. > F – Stats		0.0000	0.0000
R – Square		0.5086	0.5715
Adjusted R – Square		0.4893	0.5546

*p<0.1, **p<0.05, ***p<0.01

and thus adversely influences the environment. Such a negative impact can only be offset by implementing a recycling infrastructure for waste plastic.

To robustly check the findings presented in Table 3, we change our proxy for environmental degradation from climate change to deforestation. By using the said proxy, our findings remain the same (shown in Table 4). According to the reported results (Table 4), waste plastic pollution has a negative impact on forestation. Furthermore, the rate of waste plastic recycling has a positive relationship with forestation. These findings demonstrate that waste plastic pollution has negative effects on forestation. Similarly, a higher recycling rate of waste plastic provides a prospect for strengthening forestation.

Discussion

Waste plastics have harmful impacts that are becoming obvious and greatly contribute to environmental deterioration [67]. The toxicity of plastics is an issue in nature on a broad scale, from the level of a single plastic to the extent of plastics used without understanding their potential harm [68]. This study has demonstrated that waste plastics can have catastrophic impacts on the land, water, and air of the natural environment, as well as on animals and human health. We must act fast to address the alarming volumes of plastic garbage that have accumulated in our oceans and landfills.

The results of this study emphasize how crucial it is for corporations, governments, and citizens to take charge of trash management and embrace ecologically friendly practices. It is crucial to employ strategies like recycling, minimizing plastic use, and properly disposing of waste in order to lessen the detrimental effects of plastics on the environment. Both the long-term use of chemicals in consumer goods like thermal receipts and products that come into contact with food, drink, or children are not recommended. When it comes to reducing the use of plastic that is not necessary, each business must take responsibility for its own actions. In addition, it is crucial to deepen training and notice the natural effects of plastic waste and the demand for an overall activity to address it.

Plastic waste has a significant and far-reaching environmental impact, and immediate action is required to address this issue [69]. The recycling of waste material, particularly plastic, is extremely important because of its dangerous consequences for the environment, nature, and human health [70]. By adopting rational practices and doing whatever

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it takes to reduce plastic waste, we can work towards a cleaner, better, and more sustainable future for our planet.

Conclusions

This study contributes to the existing knowledge and literature on environmental economics and waste management by exploring the impact of waste plastic on environmental degradation. This study is in need of time as we are producing and consuming plastic in a very large quantity. Moreover, we are also facing health and environmental challenges, particularly those raised by using synthetic materials like plastic. Therefore, it is utmost important to examine the role of waste plastic in the environment, and this study attempted to fill the existing gap by doing so.

To testify to the hypothesis of the study, we collect country-level macroeconomic data from World Development Indicators (WDI) by the World Bank. The sample of the study consists of eight (8) Asian countries because of their significance towards the production and consumption of plastic and its environmental consequences. The time frame of the study is 2011-2020. The empirical data is analyzed by using various diagnostic and regression tools. The final results are in line with the previous literature and hypothesis of the study, i.e., pollution caused by waste plastic significantly harms the environment, and a higher recycling rate significantly improves the environment.

The policy implications of this study underline the need to take immediate steps regarding the production, consumption, and management of plastic. Effective policies should be made to regulate the production of plastic, promote its sustainable alternatives, and encourage its recycling practices. Moreover, it is also important to formulate and implement a well-functioning waste management system that discourages the usage of plastic and motivates the reuse and recycling of its waste. These policies and strategies are not only vital for environmental betterment but also for achieving sustainable economic growth. By moving towards a circular economy model that decreases waste and increases resource efficiency, policymakers can protect the environment, preserve resources, and create economic opportunities.

Although this study has significant policy implications, there are some limitations as well. Firstly, this study focuses on the countries of the Asian region, which may limit the generalizability of the results to other geographical regions with potentially different socioeconomic and environmental backgrounds. Secondly, this study revolves around plastic waste and its impact on environmental degradation; however, there are some other factors (e.g., transportation, industrialization, petrochemicals, etc.) that could play a significant role in pollution and environmental degradation. Future studies in the fields of waste management and environmental economics can consider other regions and cross-regional analyses. Moreover, future researchers can also include other environmental hazards to analyze their impact.

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Conflict of Interest

The authors declare no conflict of interest.

References

1. KUMAR V., SINGH E., SINGH S., PANDEY A., BHARGAVA P.C. Micro-and nano-plastics (MNPs) as emerging pollutant in ground water: Environmental impact, potential risks, limitations and way forward towards sustainable management. Chemical Engineering Journal, **459**, 141568, **2023**.
2. GREEVES S. Tracking Trash: Understanding Patterns of Debris Pollution in Knoxville's Urban Streams. Sustainability, **15** (24), 16747, **2023**.
3. CHEN Y., AWASTHI A.K., WEI F., TAN Q., LI J. Single-use plastics: Production, usage, disposal, and adverse impacts. Science of the Total Environment, **752**, 141772, **2021**.
4. EVODE N., QAMAR S.A., BILAL M., BARCELÓ D., IQBAL H.M. Plastic waste and its management strategies for environmental sustainability. Case Studies in Chemical and Environmental Engineering, **4**, 100142, **2021**.
5. KEHINDE O., RAMONU O., BABAREMU K., JUSTIN L. Plastic wastes: environmental hazard and instrument for wealth creation in Nigeria. Heliyon, **6** (10), **2020**.
6. DEY S., VEERENDRA G., BABU P.A., MANOJ A.P., NAGARJUNA K. Degradation of Plastics Waste and Its Effects on Biological Ecosystems: A Scientific Analysis and Comprehensive Review. Biomedical Materials & Devices, 1, **2023**.
7. RAHMAN M.A., MOJUMDAR S., RAHMAN S.A., MARIMUTHU K. Plastic pollutions in the ocean: their sources, causes, effects and control measures. Journal of Biological Studies, **6** (1), 37, **2023**.
8. POLPRASERT C., YEEMIN T., SUTTHACHEEP M., PUSSAYANAVIN T., JINDA K., KAMNGAM S. Marine ecosystems and emerging plastic pollution. Marine Plastics Abatement, 85, **2023**.
9. PATIL P.M., MATKAR A.R., PATIL V.B., GURAV R., DHANAVADE M.J. Removal of Heavy Metals from Industrial Wastewater Using Bioremediation Approach. In Modern Approaches in Waste Bioremediation, Springer, pp. 377, **2023**.
10. KALALI E.N., LOTFIAN S., SHABESTARI M.E., KHAYATZADEH S., ZHAO C., NEZHAD H.Y. A critical review of the current progress of plastic waste recycling

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technology in structural materials. Current Opinion in Green and Sustainable Chemistry, 100763, **2023**.
11. GAUR N., SHARMA S., YADAV N. Environmental pollution. In Green Chemistry Approaches to Environmental Sustainability, Elsevier, pp. 23, **2024**.
12. SINGH S., BISWAS M.K. Management strategies for single-use plastics: lessons to learn from Indian approach of minimizing microplastic waste. Environmental Science: Advances, **2** (12), 1680, **2023**.
13. VERMA R., VINODA K., PAPIREDDY M., GOWDA A. Toxic pollutants from plastic waste-a review. Procedia Environmental Sciences, **35**, 701, **2016**.
14. VANAPALLI K.R., SHARMA H.B., RANJAN V.P., SAMAL B., BHATTACHARYA J., DUBEY B.K., GOEL S. Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic. Science of The Total Environment, **750**, 141514, **2021**.
15. RYAN P.G., PICHEGRU L., PEROLOD V., MOLONEY C.L. Monitoring marine plastics-will we know if we are making a difference? South African Journal of Science, **116** (5-6), 1, **2020**.
16. KOLLIKKATHARA N., FENG H., STERN E. A purview of waste management evolution: Special emphasis on USA. Waste Management, **29** (2), 974, **2009**.
17. DAUVERGNE P. Why is the global governance of plastic failing the oceans? Global Environmental Change, **51**, 22, **2018**.
18. WILLIAMS M., GOWER R., GREEN J., WHITEBREAD E., LENKIEWICZ Z., SCHRÖDER P. No time to waste: Tackling the plastic pollution crisis before it's too late. Institute of Development Studies, London, **2019**.
19. THUSHARI G.G.N., SENEVIRATHNA J.D.M. Plastic pollution in the marine environment. Heliyon, **6** (8), **2020**.
20. AJIBADE F.O., ADELODUN B., LASISI K.H., FADARE O.O., AJIBADE T.F., NWOGWU N.A., SULAYMON I.D., UGYA A.Y., WANG H.C., WANG A. Environmental pollution and their socioeconomic impacts. In Woodhead Publishing Series in Food Science, Technology and Nutrition, Microbe Mediated Remediation of Environmental Contaminants, Woodhead Publishing, Elsevier, pp. 321, **2021**.
21. REDKO V., WOLSKA L., POTRYKUS M., OLKOWSKA E., CIESZYŃSKA-SEMENOWICZ M., TANKIEWICZ M. Environmental impacts of 5-year plastic waste deposition on municipal waste landfills: A follow-up study. Science of The Total Environment, **906**, 167710, **2024**.
22. HAO G., HE M., LIM S.M., ONG G.P., ZULKATI A., KAPILAN S. Recycling of plastic waste in porous asphalt pavement: Engineering, environmental, and economic implications. Journal of Cleaner Production, 140865, **2024**.
23. AGUIAR M.I., SOUSA A.F., TEIXEIRA G., TAVARES A.P., FERREIRA A.M., COUTINHO J.A. Enhancing plastic waste recycling: Evaluating the impact of additives on the enzymatic polymer degradation. Catalysis Today, **429**, 114492, **2024**.
24. AFSHAR S.V., BOLDRIN A., ASTRUP T.F., DAUGAARD A.E., HARTMANN N.B. Degradation of biodegradable plastics in waste management systems and the open environment: A critical review. Journal of Cleaner Production, 140000, **2023**.
25. CHOWDHURY S., TIWARI M., MISHRA P., PARIHAR R.S., VERMA A., MEHROTRA R., PUNJ N., SHARMA A. Recent trends of plastic waste management for sustainable environment in Indian context. Materials Today: Proceedings, **2023**.
26. PANDEY P., DHIMAN M., KANSAL A., SUBUDHI S.P. Plastic waste management for sustainable environment: techniques and approaches. Waste Disposal & Sustainable Energy, 1, **2023**.
27. TIWARI R., AZAD N., DUTTA D., YADAV B.R., KUMAR S. A critical review and future perspective of plastic waste recycling. Science of The Total Environment, 163433, **2023**.
28. IDRIS S.N., AMELIA T.S.M., BHUBALAN K., LAZIM A.M.M., ZAKWAN N.A. M.A., JAMALUDDIN M.I., SANTHANAM R., AMIRUL A.-A.A., VIGNESWARI S., RAMAKRISHNA S. The degradation of single-use plastics and commercially viable bioplastics in the environment: A review. Environmental research, **231**, 115988, **2023**.
29. AYELERU O.O., DLOVA S., AKINRIBIDE O.J., NTULI F., KUPOLATI W.K., MARINA P.F., BLENCOWE A., OLUBAMBI P.A. Challenges of plastic waste generation and management in sub-Saharan Africa: A review. Waste Management, **110**, 24, **2020**.
30. OCHIENG'WASONGA K., OKUTO E., NGUGI M.T.W. Influence of plastic waste management on the livelihoods of informal settlement residents in Kajiado north constituency, Kajiado county (Kenya). Journal of Developing Country Studies, **3** (1), 41, **2018**.
31. WANG Y., LIU Y., FENG W., ZENG S. Waste Haven Transfer and Poverty-Environment Trap: Evidence from EU. Green and Low-Carbon Economy, **1** (1), 41, **2023**.
32. BARNES D.K., GALGANI F., THOMPSON R.C., BARLAZ M. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B: Biological Sciences, **364** (1526), 1985, **2009**.
33. MARTÍN A.J., MONDELLI C., JAYDEV S.D., PEREZ-RAMIREZ J. Catalytic processing of plastic waste on the rise. Chem, **7** (6), 1487, **2021**.
34. PEDRAZA J.M. The Role of Renewable Energy in the Transition to Green, Low-carbon Power Generation in Asia. Green and Low-Carbon Economy. **2023**.
35. PAN D., SU F., LIU C., GUO Z. Research progress for plastic waste management and manufacture of value-added products. Advanced Composites and Hybrid Materials, **3**, 443, **2020**.
36. CHEN H.L., NATH T.K., CHONG S., FOO V., GIBBINS C., LECHNER A.M. The plastic waste problem in Malaysia: management, recycling and disposal of local and global plastic waste. SN Applied Sciences, **3**, 1, **2021**.
37. SAMBO U., SULE B. Impact of Climate Change on Food Security in Northern Nigeria. Green and Low-Carbon Economy. **2023**.
38. JAMBECK J.R., GEYER R., WILCOX C., SIEGLER T.R., PERRYMAN M., ANDRADY A., NARAYAN R., LAW K.L. Plastic waste inputs from land into the ocean. Science, **347** (6223), 768, **2015**.
39. ZONG H. A correlation analysis between global plastic production and floating macro-and micro-plastic waste in the ocean. International Journal of High School Research, **3** (6), 51, **2021**.
40. GEYER R., JAMBECK J.R., LAW K.L. Production, use, and fate of all plastics ever made. Science Advances, **3** (7), e1700782, **2017**.
41. MILIOS L., CHRISTENSEN L.H., MCKINNON D., CHRISTENSEN C., RASCH M. K., ERIKSEN M.H. Plastic recycling in the Nordics: A value chain market analysis. Waste Management, **76**, 180, **2018**.

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42. AKBAR A., REHMAN A., ULLAH I., ZEESHAN M., AFRIDI F.E.A. Unraveling the dynamic nexus between trade liberalization, energy consumption, CO_2 emissions, and health expenditure in Southeast Asian countries. Risk Management and Healthcare Policy, 1915, **2020**.
43. AL-SALEM S., LETTIERI P., BAEYENS J. Recycling and recovery routes of plastic solid waste (PSW): A review. Waste Management, **29** (10), 2625, **2009**.
44. BORRELLE S.B., RINGMA J., LAW K.L., MONNAHAN C.C., LEBRETON L., MCGIVERN A., MURPHY E., JAMBECK J., LEONARD G.H., HILLEARY M.A. Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. Science, **369** (6510), 1515, **2020**.
45. SHERSHNEVA E. Plastic waste: global impact and ways to reduce environmental harm. IOP Publishing, IOP Conference Series: Materials Science and Engineering, Vol. 1079, **2021**.
46. SHAH M.H., WANG N., ULLAH I., AKBAR A., KHAN K., BAH K. Does environment quality and public spending on environment promote life expectancy in China? Evidence from a nonlinear autoregressive distributed lag approach. The International Journal of Health Planning and Management, **36** (2), 545, **2021**.
47. NISAR Q.A., AKBAR A., NAZ S., HAIDER S.A., POULOVA P., HAI M.A. Greening the workforce: A strategic way to spur the environmental performance in the hotel industry. Frontiers in Environmental Science, **10**, 110, **2022**.
48. ALABI O.A., OLOGBONJAYE K.I., AWOSOLU O., ALALADE O.E. Public and environmental health effects of plastic wastes disposal: a review. Journal of Toxicological Risk Assessment, **5** (021), 1, **2019**.
49. WARING R.H., HARRIS R., MITCHELL S. Plastic contamination of the food chain: A threat to human health? Maturitas, **115**, 64, **2018**.
50. KHAN S., AKBAR A., NASIM I., HEDVIČÁKOVÁ M., BASHIR F. Green finance development and environmental sustainability: A panel data analysis. Frontiers in Environmental Science, **10**, 2134, **2022**.
51. NAIDU R., BISWAS B., WILLETT I.R., CRIBB J., SINGH B.K., NATHANAIL C. P., COULON F., SEMPLE K.T., JONES K.C., BARCLAY A. Chemical pollution: A growing peril and potential catastrophic risk to humanity. Environment International, **156**, 106616, **2021**.
52. KUMAR R., VERMA A., SHOME A., SINHA R., SINHA S., JHA P.K., KUMAR R., KUMAR P., SHUBHAM, DAS S. Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. Sustainability, **13** (17), 9963, **2021**.
53. KHOAELE K.K., GBADEYAN O.J., CHUNILALL V., SITHOLE B. The Devastation of Waste Plastic on the Environment and Remediation Processes: A Critical Review. Sustainability, **15** (6), 5233, **2023**.
54. AKBAR M., HUSSAIN A., AKBAR A., ULLAH I. The dynamic association between healthcare spending, CO_2 emissions, and human development index in OECD countries: Evidence from panel VAR model. Environment, development and sustainability, **23**, 10470, **2021**.
55. DORÉ N.I., TEIXEIRA A.A. Empirical literature on economic growth, 1991-2020: Uncovering extant gaps and avenues for future research. Global Journal of Emerging Market Economies, **15** (1), 7, **2023**.
56. MOSLEHPOUR M., ALDEEHANI T.M., SIBGHATULLAH A., TAI T.D., PHAN T.T.H., NGO T.Q. Dynamic association between technological advancement, green finance, energy efficiency and sustainable development: evidence from Vietnam. Economic Research-Ekonomska Istraživanja, **36** (3), 2190796, **2023**.
57. KUMARI S., KAUSHIK D.S. Impact of Artificial Intelligence on Human Resource. Contemporary Trends & Challenges In Commerce, 177, **2023**.
58. MUHAMAD G.M. Data Presentation and Analysis. Springer, **2023**.
59. BARTRAM J., BALLANCE R. Water quality monitoring: a practical guide to the design and implementation of freshwater quality studies and monitoring programmes. CRC Press, **1996**.
60. PAULY D., CHRISTENSEN V., GUÉNETTE S., PITCHER T.J., SUMAILA U.R., WALTERS C.J., WATSON R., ZELLER D. Towards sustainability in world fisheries. Nature, **418** (6898), 689, **2002**.
61. PIMM S.L., JENKINS C.N., ABELL R., BROOKS T.M., GITTLEMAN J.L., JOPPA L.N., RAVEN P.H., ROBERTS C.M., SEXTON J.O. The biodiversity of species and their rates of extinction, distribution, and protection. Science, **344** (6187), 1246752, **2014**.
62. TILMAN D., CLARK M., WILLIAMS D.R., KIMMEL K., POLASKY S., PACKER C. Future threats to biodiversity and pathways to their prevention. Nature, **546** (7656), 73, **2017**.
63. BAI S., KOLTER J.Z., KOLTUN V. An empirical evaluation of generic convolutional and recurrent networks for sequence modeling. Computer Science, Machine Learning, **1**, **2018**.
64. LELIEVELD J., KLINGMÜLLER K., POZZER A., PÖSCHL U., FNAIS M., DAIBER A., MÜNZEL T. Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions. European Heart Journal, **40** (20), 1590, **2019**.
65. KAWECKI D., NOWACK B. A proxy-based approach to predict spatially resolved emissions of macro-and microplastic to the environment. Science of the Total Environment, **748**, 141137, **2020**.
66. LIETO A., VERGINELLI I., ZINGARETTI D., LOMBARDI F. Total organic carbon as a proxy for metal release from biostabilized wastes. Environmental Science and Pollution Research, **28**, 24650, **2021**.
67. CAI Z., LI M., ZHU Z., WANG X., HUANG Y., LI T., GONG H., YAN M. Biological degradation of plastics and microplastics: A recent perspective on associated mechanisms and influencing factors. Microorganisms, **11** (7), 1661, **2023**.
68. HALDAR S., MURALIDARAN Y., MÍGUEZ D., MULLA S.I., MISHRA P. Eco-toxicity of nano-plastics and its implication on human metabolism: Current and future perspective. Science of The Total Environment, **861**, 160571, **2023**.
69. JAKHAR R., SAMEK L., STYSZKO K. A Comprehensive Study of the Impact of Waste Fires on the Environment and Health. Sustainability, **15** (19), 14241, **2023**.
70. PLATON V., PAVELESCU F.M., SURUGIU M., FRONE S., MAZILESCU R., CONSTANTINESCU A., POPA F. Influence of Eco-Innovation and Recycling on Raw Material Consumption; Econometric Approach in the Case of the European Union. Sustainability, **15** (5), 3996, **2023**.