



Article

Environmental Policy for the Restriction on the Use of Plastic Products in Taiwan: Regulatory Measures, Implementation Status and COVID-19's Impacts on Plastic Products Recycling

Wen-Tien Tsai

Graduate Institute of Bioresources, National Pingtung University of Science and Technology, Pingtung 912, Taiwan; wttsai@mail.npust.edu.tw; Tel.: +886-8-7703202

Abstract: In response to international trends regarding the reduction in plastic waste (or plastic pollution), this work used the official statistics that were recently released, focusing on regulatory actions restricting the use of plastic products and/or the increase in recycling in Taiwan. In addition, the impacts of the COVID-19 pandemic on plastic waste generation and plastic products' recycling were also addressed in the present study. The results showed that the plastic compositions in the garbage slightly increased in recent years, suggesting that the effect of restrictions on the use of plastic products in Taiwan was not significant, even though the regulatory measures have been implemented since 2002. However, chlorine contents in the garbage were significantly increased in 2020. The increase could be attributed to the fact that kitchen waste (containing salt), household waste containing disinfectant (e.g., chlorine dioxide, sodium hypochlorite) or PVC-made products were generated more during the COVID-19 pandemic. Furthermore, the data also indicated that the monthly quantities of recycled plastic containers and other plastic products had no significant change since January 2020, especially in the outbreak period from May 2021 to July 2021.



Citation: Tsai, W.-T. Environmental Policy for the Restriction on the Use of Plastic Products in Taiwan: Regulatory Measures, Implementation Status and COVID-19's Impacts on Plastic Products Recycling. *Environments* **2022**, *9*, 7. <https://doi.org/10.3390/environments9010007>

Academic Editor: Dimitrios Komilis

Received: 7 December 2021

Accepted: 29 December 2021

Published: 4 January 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Keywords: plastic waste; plastic products; trend analysis; regulatory measures; restricted consumption; COVID-19 pandemic

1. Introduction

Due to their lightweight, hygienic, waterproof, low-cost, durable and aesthetic features, plastic products have played an indispensable role in everyone's day over the past decades. These plastics are mostly made from synthetic resins, including polyethylene terephthalate (PET), high-density/low-density polyethylene (HDPE/LDPE), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), and expanded polystyrene (EPS) [1]. However, an increase in the use of single-use plastics has led to dramatic environmental pollution, especially in the marine environment [2]. Marine debris or microplastic pollution were recently reviewed by scientists in different fields [2–9]. Marine pollution is originally caused by a variety of plastic products, which are broken down into fine pieces by mechanical and weathering processes, eventually forming so-called microplastics (MPs). These MPs may have negative effects on aquatic organisms and various species after they are ingested [10]. Therefore, policies or strategies restricting the uses of single-use plastics (e.g., plastic bags, plastic straws) in a circular economy have been adopted by various countries, such as USA, European Union (EU) and Taiwan [11–14]. Furthermore, the United Nations launched the sustainable development goals (SDGs) in 2015 as part of the 2030 Agenda for Sustainable Development, with a 15-year plan to achieve these goals [15]. The 14th SDGs was to “conserve and sustainably use the oceans, seas and marine resources”, as the ocean covers nearly three quarters of the Earth's surface and contains about 97% of the Earth's water. On World Environment Day 2018, the United Nations Industrial Development Organization (UNIDO) addressed the theme of “Beat plastic pollution”, which aimed to reduce the

negative effects of plastic waste (or plastic pollution) on people's health and wildlife by taking actions restricting the use of plastic products and/or encouraging their recycling [16].

In line with international policies for the reduction in plastic waste and the restriction on the uses of single-use plastics, the central competent authority in Taiwan (i.e., Environmental Protection Administration (EPA)) initially promulgated the reduction and recycling system of regulated recyclable waste (e.g., plastic containers) from municipal solid waste (MSW) based on the Waste Management Act (WMA) [14]. Table 1 summarizes the regulatory policies for recycling resources from MSW since 1997. The 4-in-1 Recycling Program covered the public community, local authorities (cleaning teams), recycling enterprises, and recycling fund [17]. Under the extended producer responsibility (EPR) principle, the product manufacturers and importers funded the program, which then subsidizes collection and recycling by licensed enterprises. Citizens must classify their household waste into the recyclable, non-recyclable, and organic (food) waste items. The program also encourages them to recycle because it only allows non-recyclables in the special plastic bags. Citizens in Taipei city (Taiwan) must purchase these bags; the bigger the bag, the greater the price. The statistical database by the EPA [18] showed that the overall recycling rate was increased from 5.8% in 2000 to 58.9% in 2020. However, plastics in the non-recyclable garbage still contributed to 15–20% of the weight, showing that plastic products, including single-use plastics, were still overused by the public in Taiwan. Therefore, the Taiwan EPA has restricted the use of plastic bags since 2006 and has continued to announce more restrictions on the use of plastic products, under the authorization of the WMA [14].

Table 1. Main policies for recycling resources from municipal solid waste (MSW) in Taiwan.

Implementation Year	Main Policies	Comments
1988	Extended producer responsibility (EPR) incorporated	Incorporated into the Waste Management Act (WMA)
1997	4-in-1 Recycling Program announced	A special feedback mechanism covers the public community, local authorities (cleaning teams), recycling enterprises, and recycling fund. The fees are collected from responsible manufacturers and importers.
2000	Trash collection fee per bag	Only implemented in Taipei city
2001	Food waste (kitchen waste) recycling	Mainly reused as pig feed and organic compost
2003	Bulk waste recycling	Bulk waste mainly includes discarded furniture, which may still be reused after minor repairs.
2005	Compulsory MSW sorting	MSW must be sorted into garbage (general waste), food waste, recyclable waste and bulk waste.
2010	Sustainable material management (SMM) introduced	Using the cradle-to-cradle principle by life cycle assessment and material flow analysis
2017	Diversified MSW Treatment Program	Focusing on waste-to-energy promotion and food waste-to-biopower

Although the regulatory measures for plastic waste reduction and recycling and the discussions regarding COVID-19's impact on plastic waste have been addressed in the previous study [14], updated data had not yet been provided to support the expected increase in the generation of plastic waste. With the official statistics that were recently released [19], this paper focuses on three important themes. First, the regulatory measures and policies restricting the use of plastic products were reviewed. Subsequently, the implementation results of restrictions on the use of plastic products were addressed to verify the effectiveness of these regulatory measures. Finally, the impacts of the COVID-19 pandemic on restrictions on the use of plastic products were discussed, to ensure that they were in accordance with the increase in recycled plastic waste and the plastic containers.

2. Data Mining and Methodology

As mentioned above, the main purposes of this study were to address the updated status of regulatory measures restricting the use of plastic products and the results of their implementation, and also analyze the impacts of COVID-19 on this policy. Therefore, regulatory measures and statistical database relevant to the restriction of the use of plastic products in Taiwan were based on the following:

- Regulatory measures and policies for the restriction on the use of plastic products.

Regarding the restrictions on the use of plastic products, the regulations were accessed on the official website [20]. In addition, the environmental policies for this issue or marine waste control strategies were obtained from the EPA website to echo the regulatory measures [21,22].

- Implementation status of restrictions on the use of plastic products.

In order to review the implementation status of restrictions on the use of plastic products in Taiwan, the updated data for the recycled plastic containers and other plastic products were extracted from the official yearbook [18] and the Solid Waste Statistics (EPA, Taiwan) [19]. In addition, the garbage composition by chlorine in recent years (2016–2020) was further analyzed to observe the variations during the COVID-19 pandemic.

- Impacts of COVID-19 pandemic on plastic products' recycling.

Figure 1 showed the data on the daily confirmed COVID-19 cases during the period of January 2020–October 2021 [23], indicating a significant increase in epidemic alerts since May 2021. To analyze the impacts that the COVID-19 pandemic had on the restrictions on the use of plastic products and their recycling, the monthly variations in the plastic containers and other plastics recycled by the agencies from January 2020 to July 2021 were used in this work [18,23].

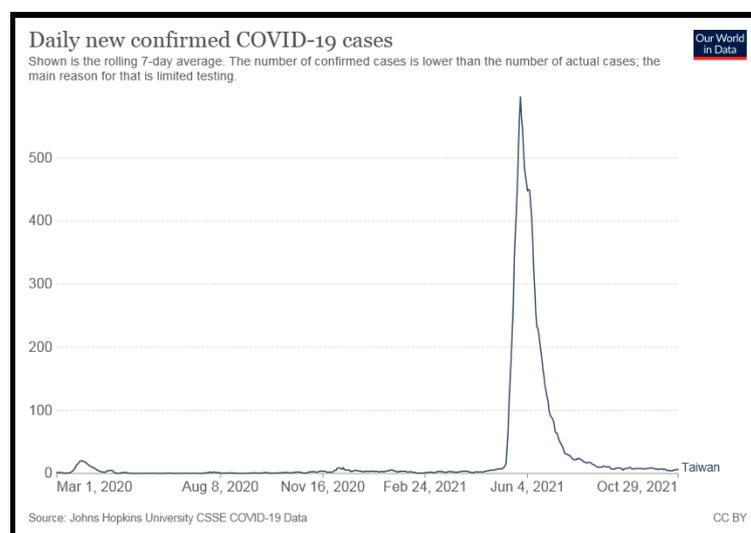


Figure 1. 7-day average confirmed COVID-19 cases in Taiwan [23].

3. Results and Discussion

3.1. Regulatory Measures and Plans for Restriction on the Use of Plastic Products

In Taiwan, the legal framework for the restrictions on the use of plastic products was authorized by the WMA and the Resource Recycling Act (RRA) [20,22]. According to Article 21 of the WMA, the central competent authority (i.e., EPA) may officially prohibit the use of, or announce restrictions on, the manufacturing, import, sales and use of those articles, packaging and containers, due to concerns regarding serious environmental pollution. In the RRA, the Article 13 empowers the EPA to announce and designate the restriction

of or reduction in the use of goods, packaging, or containers. In order to reduce the generation of plastic waste and respond to international environmental issues in recent years, such as SDGs [15] and marine pollution [16], the EPA completely revised the WMA in October 2001, thus forming the legal principle for restrictions on the use of plastic products. Prior to the promulgation of the relevant regulations restricting the use of plastic products, the EPA announced the policy for the restriction on the uses of plastic shopping bags and plastic disposable dishes in May 2002, with two implementation stages. The first stage targeted the shops (or stores) of government agencies, schools, hospitals, state-owned enterprises and military organizations, which were required to restrict the use of plastic shopping bags and plastic disposable dishes after 1 July 2002 and 1 October 2002, respectively. The second stage, implemented on 1 January 2003, expanded the targeted shops (or stores) of the following businesses: department stores, wholesaler/retailers (mega stores), franchised supermarkets, convenience stores, fast food franchises (chains), and other food and beverage establishments (not including street vendors and food stalls). With the implementation of the “pilot” policy of restrictions on the use of commonly used plastic products during the period of 2003–2005, the EPA analyzed the positive results of plastic waste reduction and conducted a usage audit, and formally promulgated the relevant regulations since 2006. As summarized in Table 2, the EPA announced the relevant regulations restricting the use of plastic products, which were described in the previous study [14].

Table 2. Major regulations governing the restrictions on the use of plastic products in Taiwan.

Regulation	Announcement Date	Lastest Revision	
		Announcement Date	Effective Day
Plastic Shopping Bag Restriction Targets, Implementation, and Date of Implementation	9 June 2006	15 August 2017	1 January 2018 (Penalty since 1 January 2019)
Plastic Disposable Tableware Restriction Targets, Implementation, and Date of Implementation	9 June 2006	8 August 2019	8 August 2019
Restriction on the Use of Plastic Pallets and Packaging Boxes	28 March 2007	23 December 2011	1 January 2012
Ban on Manufacturing, Import, and Sale for Cosmetics and Personal Care Products Containing Plastic Microbeads	3 August 2017	– ^a	1 January 2018 (Ban on Manufacturing, Import) 1 July 2018 (Ban on sale)
Single-Use Plastic Straw Restriction Targets and Implementation	8 May 2019	–	1 July 2019 (Penalty since 1 July 2020)

^a Not available.

In response to the Goal 14 in the SDGs, the “Taiwan Marine Debris Management Platform” was jointly set up by the EPA and civil organizations in July 2017. The Plan (“Taiwan Marine Debris Governance Action”) contained the following actions [21]:

1. Source reduction:
 - Strategy 1: Regulatory implementation restricting the use of plastic products (as summarized in Table 2).
 - Strategy 2: Extended producer responsibilities for corporations under the principles of zero-waste and the circular economy.
2. Prevention and removal:
 - Strategy 1: Effective removal of floating wastes in hotspots (i.e., harbors, ports) using special machinery or workforces.

- Strategy 2: Stopping waste (floating wastes on the rivers or streams) from entering oceans.
 - Strategy 3: Education and promotion of public participation of coordinating civic organizations, the adopting organizations or bodies, and city- and county-cleaning units.
3. Research and investigation:
 - Strategy 1: Understanding coastal and marine pollution in Taiwan via research and monitoring, including the impacts marine waste has on living organisms, the ecosystem, human societies and the economy.
 - Strategy 2: Education and promotion of public participation in marine waste monitoring and cleaning.
 4. Expansion of collaboration and participation:
 - Strategy 1: Expansion and strengthening of multilateral collaboration with South-east Asia on marine waste issues.
 - Strategy 2: Expansion of public awareness and social concerns through environmental education programs.

3.2. Implementation Results of Restriction on the Use of Plastic Products

Since the 1990s, Taiwan has become one of the major regions for the manufacture of plastic products around the world, as plastics were encouraged to reduce costs and the risk of certain diseases (e.g., hepatitis) spreading. As described in Section 3.1, the Taiwanese government introduced a plastic bag levy has been in place from in 2002, thus reducing plastic bag use by more than 59% [24]. Taiwan developed its recycling industry into a successful circular economy model using the 4-in-1 Recycling Program in 1997 [14,25]. Figure 2 shows the variations in the generated MSW and its type in Taiwan in recent years (2018–2020). Herein, the waste generated by employees in these industries has been incorporated into MSW since 2018, thus indicating a significant increase, from 7871 thousand metric tons in 2017 to 9741 thousand metric tons in 2018 [18]. An increase was also shown in recyclable waste, including a variety of containers, such as metal, glass, Tetra Pak, paper, and plastics. Table 3 summarizes the reported amounts of plastic containers and other plastic products recycled by implementing agencies in Taiwan since 2016, indicating an increasing trend that was unaffected by the COVID-19 pandemic. However, the compositions of plastics in the garbage showed a slight increase in recent years, as seen in Table 4 and shown in Figure 3. The reasons for this change could be attributed to the decline in the recycling of plastic products and “Diversified MSW Treatment Program” promoting waste-to-power. In this regard, the restrictions on the use of plastic products in Taiwan was not significant, even though regulatory measures have been implemented for 15 years. Figure 3 additionally indicated a significant increase in chlorine content in 2020, reflecting that kitchen waste (containing salt), household waste containing disinfectant (e.g., chlorine dioxide, sodium hypochlorite) or PVC-made products were generated during the COVID-19 pandemic. Therefore, some toxic compounds, such as dioxins, may be released in greater amounts from MSW incineration plants [2].

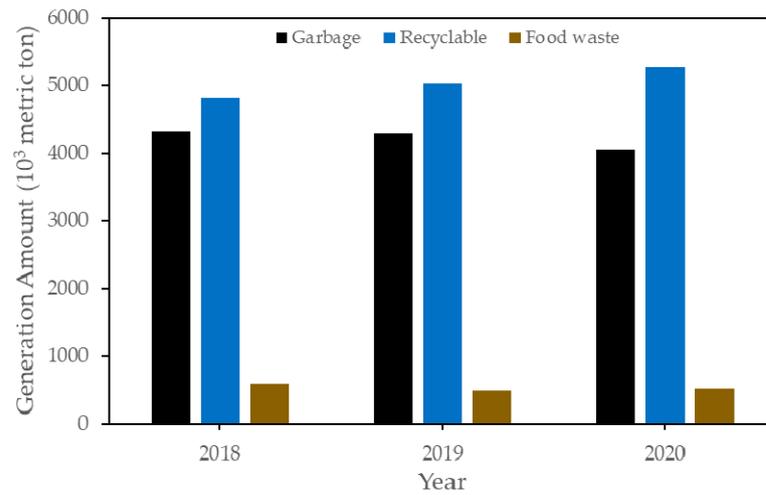


Figure 2. Variations in the generated amounts of MSW and their type in Taiwan since 2018 [18].

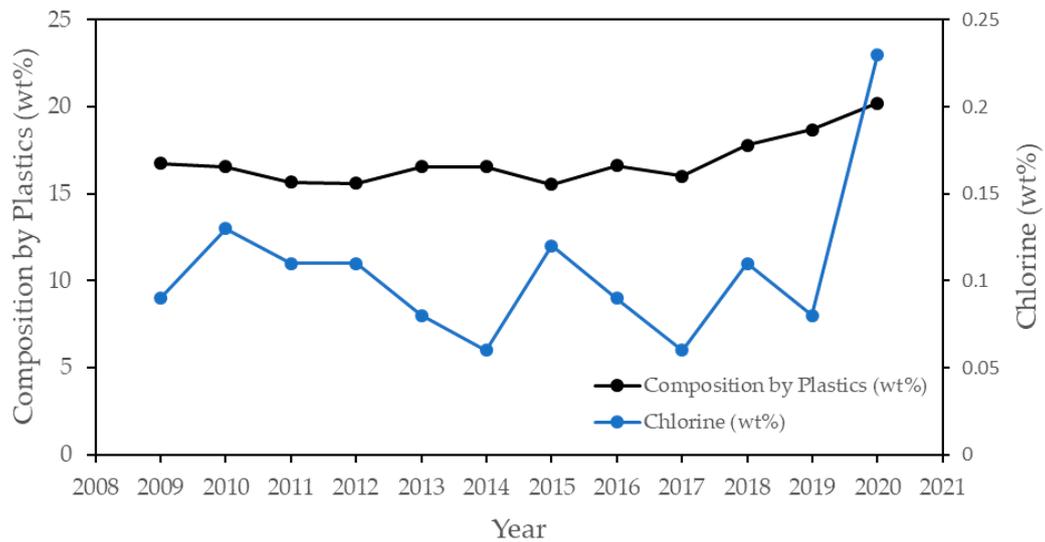


Figure 3. Variations in garbage compositions by plastics and elemental chlorine during the period of 2009–2020 [18].

Table 3. Reported amounts of plastic containers and other plastic products recycled by implementing agencies in Taiwan since 2016 ¹.

Year	Plastic Containers	Other Plastic Products
2016	262,972	57,060
2017	301,926	82,271
2018	367,741	95,872
2019	413,992	110,738
2020	459,802	140,980
First half of 2020	215,279	67,320
Second half of 2020	244,523	73,660
First half of 2021	223,670	70,514

¹ Source [18,19]; unit: metric ton.

Table 4. Reported amounts of garbage (general waste) generation, proximate analysis and composition by plastics in Taiwan since 2018 ¹.

Year	Garbage Generation (Metric Ton)	Proximate Analysis (wt%)			Composition by Plastics ² (wt%)
		Moisture	Ash	Combustibles	
2016	3,133,582	52.91	6.28	40.81	16.61
2017	3,130,735	52.60	6.07	41.33	16.00
2018	4,317,339	50.77	6.12	43.10	17.79
2019	4,290,856	48.49	6.63	44.88	18.67
2020	4,062,029	45.34	9.27	45.40	20.20

¹ Source [18]. ² Wet basis.

3.3. Impacts of COVID-19 Pandemic on Plastic Products Recycling

The regulatory lockdown measures resulting from the COVID-19 pandemic may have had huge impacts on environmental issues, including air quality and waste management [26–31]. Regarding the impacts of COVID-19 event on plastic waste management, there was an increased generation of plastic waste caused by the excessive consumption of single-use plastics due to the need for temporary relief and plastic-wrapped articles (e.g., disinfectants and spray bottles) during the pandemic [32–37]. In addition, the most common materials reused in face masks include non-woven fibrous plastics such as polypropylene (PP) [38], also causing the increase in plastics or plastic waste during the COVID-9 pandemic.

In early 2020, Taiwan started to implement proactive measures against the COVID-19 pandemic. As shown in Figure 1, the profile of confirmed COVID-19 cases indicated a successful epidemic prevention by the use of regulatory measures (e.g., contact-tracing, testing, face-masking, social distancing, and quarantine) and innovative information technology, which jointly worked with the National Health Insurance (NHI) system and the National Central Epidemic Command Center (CECC). Although the CECC announced Alert Level 2 before April 2021, during the pandemic, Taiwan’s economic and daily living activities continued as usual, with overseas Taiwanese returning to the island. This smooth situation came to an end in mid-May 2021 when an outbreak of COVID-19 transmission has broken out everyday life for about two months. As the CECC raised the national epidemic alert to the Level 3 on 19 May 2021, the COVID-19 confirmed cases significantly fell from August 2021 to October 2021. New cases per day fell from 535 on 17 May 2021 to an average of fewer than 3 in October 2021. In response to the COVID-19 outbreak in May 2021, the Taiwan EPA allowed regulated enterprises to apply to local competent authorities for exemptions from the prohibition on the use of disposable plastic tableware. Once approved, they were allowed to use disposable tableware made of materials other than plastics for up to 90 days. Concerning the impact of the COVID-19 outbreak on the amounts of plastic containers and other plastic products that were recycled, Figure 4 depicted the monthly variations in plastic containers and other plastic products that were recycled by the implementing agencies from January 2020 to July 2021. The results showed that there was no significant change in the quantities of recycled plastic containers and other plastic products since January 2020, especially in the outbreak period from May 2021 to July 2021.

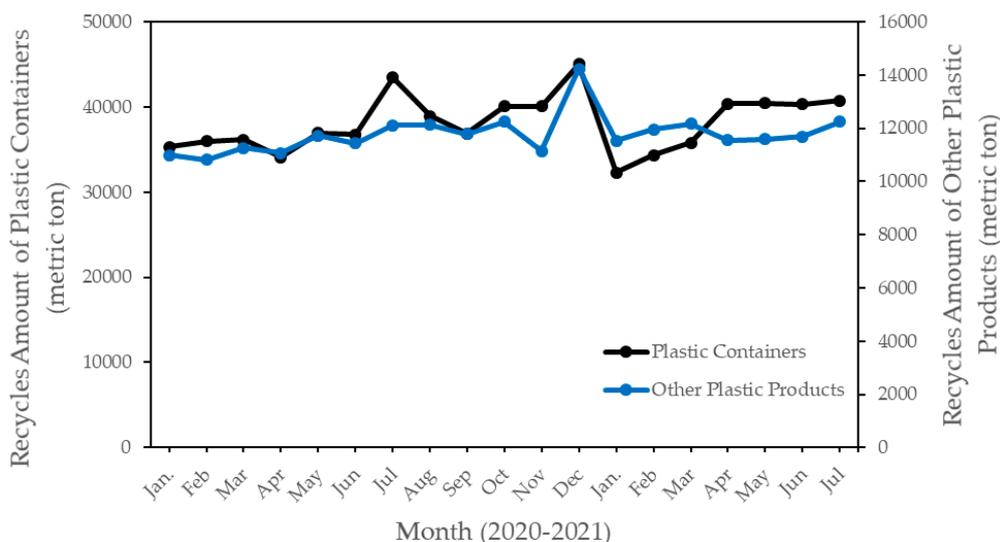


Figure 4. Monthly variations in plastic containers and other plastic products recycled by implementing agencies from January 2020 to July 2021 [19].

4. Conclusions

This work may be the first study on the impacts of the COVID-19 pandemic on plastic waste generation and plastic products' recycling in Taiwan during the period of 2020–2021 (up to July). Based on the official statistics by the Taiwan EPA, the reported amounts of plastic containers and other plastic products that were recycled by implementing agencies indicated an increasing trend and were unaffected by the COVID-19 pandemic in 2020. However, the amount of plastics in the garbage showed a slight increase in recent years (2017–2020), suggesting that restrictions on the use of plastic products in Taiwan were not significant, even though these regulatory measures have been implemented since 2002. On the other hand, the chlorine content in the garbage showed a significant increase in 2020. The increase could be attributable to the fact that kitchen waste (containing salt), household waste containing disinfectants (e.g., chlorine dioxide, sodium hypochlorite, or other chlorine-containing disinfectants) or PVC-made products were generated more during the COVID-19 pandemic. Furthermore, the data also showed that the quantities of recycled plastic containers and other plastic products showed no significant change since January 2020, especially in the outbreak period from May 2021 to July 2021. Concerning the goal of zero plastic waste being achieved by 2030, the reduction rates of regulated plastic containers or single-use plastic products in Taiwan should be enhanced by the adoption of more compulsory measures against plastic pollution using relevant laws, such as a ban on the use of certain single-use plastic products.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Rhyner, C.R.; Schwartz, L.J.; Wenger, R.B.; Kohrell, M.G. *Waste Management and Resource Recovery*; CRC Press: Boca Raton, FL, USA, 1995.
2. Sharma, S.; Chatterjee, S. Microplastic pollution, a threat to marine ecosystem and human health: A short review. *Environ. Sci. Pollut. Res.* **2017**, *24*, 21530–21547. [[CrossRef](#)]

3. Yu, Y.; Zhou, D.; Li, Z.; Zhu, C. Advancement and challenges of microplastic pollution in the aquatic environment: A review. *Water Air Soil Pollut.* **2018**, *229*, 140. [CrossRef]
4. Ng, E.-L.; Lwanga, E.H.; Eldridge, S.M.; Johnston, P.; Hu, H.-W.; Geissen, V.; Chen, D. An overview of microplastic and nanoplastic pollution in agroecosystems. *Sci. Total Environ.* **2018**, *627*, 1377–1388. [CrossRef] [PubMed]
5. Peixoto, D.; Pinheiro, C.; Amorim, J.; Oliva-Teles, L.; Guilhermino, L.; Vieira, M.N. Microplastic pollution in commercial salt for human consumption: A review. *Estuar. Coast. Shelf Sci.* **2019**, *219*, 161–168. [CrossRef]
6. Reimonn, G.; Lu, T.; Gandhi, N.; Chen, W.-T. Review of microplastic pollution in the environment and emerging recycling solutions. *J. Renew. Mater.* **2019**, *7*, 1251–1268. [CrossRef]
7. Pirsahab, M.; Hossini, H.; Makhdoumi, P. Review of microplastic occurrence and toxicological effects in marine environment: Experimental evidence of inflammation. *Process Saf. Environ. Prot.* **2020**, *142*, 1–14. [CrossRef]
8. Tang, Y.; Liu, Y.; Chen, Y.; Zhang, W.; Zhao, J.; He, S.; Yang, C.; Zhang, T.; Tang, C.; Zhang, C.; et al. A review: Research progress on microplastic pollutants in aquatic environments. *Sci. Total Environ.* **2021**, *766*, 142572. [CrossRef]
9. Zhang, K.; Hamidian, A.H.; Tubić, A.; Zhang, Y.; Fang, J.K.; Wu, C.; Lam, P.K. Understanding plastic degradation and microplastic formation in the environment: A review. *Environ. Pollut.* **2021**, *274*, 116554. [CrossRef] [PubMed]
10. Auta, H.S.; Emenike, C.U.; Fauziah, S.H. Distribution and importance of microplastics in the marine environment: A review of the sources, fate, effects, and potential solutions. *Environ. Int.* **2017**, *102*, 165–176. [CrossRef] [PubMed]
11. Wagner, T.P. Reducing single-use plastic shopping bags in the USA. *Waste Manag.* **2017**, *70*, 3–12. [CrossRef]
12. Xanthos, D.; Walker, T.R. International policies to reduce plastic marine pollution from single-use plastics (plastic bags and microbeads): A review. *Mar. Pollut. Bull.* **2017**, *118*, 17–26. [CrossRef]
13. Matthews, C.; Moran, F.; Jaiswal, A.K. A review on European Union’s strategy for plastics in a circular economy and its impact on food safety. *J. Clean. Prod.* **2021**, *283*, 125263. [CrossRef]
14. Tsai, W.T. Analysis of plastic waste reduction and recycling in Taiwan. *Waste Manag. Res.* **2021**, *39*, 713–719. [CrossRef]
15. United Nations. Take Action for the Sustainable Development Goals. Available online: <https://www.un.org/sustainabledevelopment/sustainable-development-goals/> (accessed on 3 November 2021).
16. United States Environment Programme. On World Environment Day 2018. Available online: <https://www.unep.org/events/un-environment-event/world-environment-day-2018> (accessed on 3 November 2021).
17. Recycling Fund Management Board. Available online: <https://recycle2.epa.gov.tw/EN/index.html> (accessed on 3 November 2021).
18. Environmental Protection Administration (EPA). *Yearbook of Environmental Protection Statistics*; EPA: Taipei, Taiwan, 2021.
19. EPA. Solid Waste Statistics. Taiwan. Available online: <https://www.epa.gov.tw/ENG/513B0B39D090DE4C> (accessed on 3 November 2021).
20. Laws and Regulation Retrieving System (Ministry of Justice, Taiwan). Available online: <https://law.moj.gov.tw/Eng/index.aspx> (accessed on 13 October 2021).
21. Major Environmental Policies: Marine Waste Control Strategies. Available online: <https://www.epa.gov.tw/DisplayFile.aspx?FileID=F00732FAD4EA7C3&P=e42bdddb-c388-4bc7-a360-4d1ebe7cc7c4> (accessed on 4 November 2021).
22. EPA. Resources Circulation. Taiwan. Available online: <https://www.epa.gov.tw/eng/C35324133BC7ABB3> (accessed on 10 November 2021).
23. Our World in Data. Available online: <https://ourworldindata.org/coronavirus/country/taiwan> (accessed on 31 December 2021).
24. Taiwan Plastics Industry Statistics, Trends & Analysis. Available online: <https://brandongaille.com/20-taiwan-plastics-industry-statistics-trends-analysis/> (accessed on 9 November 2021).
25. Wu, C.Y.; Hu, M.C.; Ni, F.C. Supporting a circular economy: Insights from Taiwan’s plastic waste sector and lessons for developing countries. *Sustain. Prod. Consum.* **2021**, *26*, 228–238. [CrossRef] [PubMed]
26. Bashir, M.; MA, B.; Shahzad, L. A brief review of socio-economic and environmental impact of COVID-19. *Air Qual. Atmos. Health* **2020**, *13*, 1403–1409. [CrossRef]
27. Cheval, S.; Adamescu, C.M.; Georgiadis, T.; Herrnegger, M.; Piticar, A.; Legates, D.R. Observed and potential impacts of the COVID-19 pandemic on the environment. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4140. [CrossRef]
28. Shakil, M.H.; Munim, Z.H.; Tasnia, M.; Sarowar, S. COVID-19 and the environment: A critical review and research agenda. *Sci. Total Environ.* **2020**, *745*, 141022. [CrossRef]
29. Zambrano-Monserrate, M.A.; Ruano, M.A.; Sanchez-Alcalde, L. Indirect effects of COVID-19 on the environment. *Sci. Total Environ.* **2020**, *728*, 138813. [CrossRef]
30. Khan, I.; Shah, D.; Shah, S.S. COVID-19 pandemic and its positive impacts on environment: An updated review. *Int. J. Environ. Sci. Technol.* **2020**, *18*, 521–530. [CrossRef] [PubMed]
31. Cai, M.; Guy, C.; Héroux, M.; Lichtfouse, E.; An, C. The impact of successive COVID-19 lockdowns on people mobility, lockdown efficiency, and municipal solid waste. *Environ. Chem. Lett.* **2021**, *19*, 3959–3965. [CrossRef] [PubMed]
32. Kulkarni, B.N.; Anantharama, V. Repercussions of COVID-19 pandemic on municipal solid waste management: Challenges and opportunities. *Sci. Total Environ.* **2020**, *743*, 140693. [CrossRef] [PubMed]
33. Das, A.K.; Islam, M.N.; Billah, M.M.; Sarker, A. COVID-19 and municipal solid waste (MSW) management: A review. *Environ. Sci. Pollut. Res.* **2021**, *28*, 28993–29008. [CrossRef] [PubMed]
34. Sarkodie, S.A.; Owusu, P.A. Impact of COVID-19 pandemic on waste management. *Environ. Dev. Sustain.* **2021**, *23*, 7951–7960. [CrossRef]

35. Torkashvand, J.; Jafari, A.J.; Godini, K.; Kazemi, Z.; Kazemi, Z.; Farzadkia, M. Municipal solid waste management during COVID-19 pandemic: A comparison between the current activities and guidelines. *J. Environ. Health Sci. Eng.* **2021**, *19*, 173–179. [[CrossRef](#)] [[PubMed](#)]
36. Vaverková, M.D.; Paleologos, E.K.; Dominijanni, A.; Koda, E.; Tang, C.-S.; Małgorzata, W.; Li, Q.; Guarena, N.; Mohamed, A.-M.O.; Vieira, C.S.; et al. Municipal solid waste management under COVID-19: Challenges and recommendations. *Environ. Geotech.* **2021**, *8*, 217–232. [[CrossRef](#)]
37. Yousefi, M.; Oskoei, V.; Jafari, A.J.; Farzadkia, M.; Firooz, M.H.; Abdollahinejad, B.; Torkashvand, J. Municipal solid waste management during COVID-19 pandemic: Effects and repercussions. *Environ. Sci. Pollut. Res.* **2021**, *28*, 32200–32209. [[CrossRef](#)]
38. O'Dowd, K.; Nair, K.M.; Forouzandeh, P.; Mathew, S.; Grant, J.; Moran, R.; Bartlett, J.; Bird, J.; Pillai, S.C. Face masks and respirators in the fight against the COVID-19 pandemic: A review of current materials, advances and future perspectives. *Materials* **2020**, *13*, 3363. [[CrossRef](#)] [[PubMed](#)]