Scientific Research Publishing

Current Urban Studies, 2022, 10, 249-262
https://www.scirp.org/journal/cus
ISSN Online: 2328-4919
ISSN Print: 2328-4900

Study of Litter on Delaware Roadways

Kasra Karimi, Ardeshir Faghri

Department of Civil and Environmental Engineering, University of Delaware, Newark, USA
Email: faghri@udel.edu

How to cite this paper: Karimi, K., & Faghri, A. (2022). Study of Litter on Delaware Roadways. *Current Urban Studies, 10,* 249-262.
https://doi.org/10.4236/cus.2022.102015

Received: April 28, 2022
Accepted: June 6, 2022
Published: June 9, 2022

Abstract

Roadside litter has been a persistent issue in Delaware. In addition to all the efforts from volunteer programs, the Delaware Department of Transportation (DelDOT) spends nearly $2 million annually for removing and disposing of roadside litter and illegal dumping. The increase in the number of people, vehicles, and products has led to an increase in certain types of litter on the roads. Additionally, the emergence of the global pandemic due to COVID-19 has drastically aggravated the problem, particularly, due to the enormous increase in the demand and use of Personal Protective Equipment (PPE) and plastic products used for packaging and take-out foods. The existing publications that address the issue of roadside litter in Delaware are few in number and scattered. The goal of this study is to present concise yet comprehensive information about the extent of these issues and the current litter abatement efforts in Delaware and to introduce suggestions for mitigating this problem. For this purpose, a collection of relevant documents, including academic and non-academic literature, have been reviewed and summarized. The issue of roadside litter is a complex problem with numerous environmental, social, and economic impacts. Further, litter and other types of debris on the roads can pose serious safety hazards for road users. Although multiple positive steps have been taken recently to tackle this issue in Delaware, more comprehensive and effective strategies need to be established for boosting the current measures. Some major areas for improvement include, but are not limited to, enhancing education and public awareness programs, encouraging volunteer campaigns, establishing more effective law enforcement methods, and improving the disposal facilities.

Keywords

Litter, Illegal Dumping, Road, Delaware

1. Introduction

Forbes (2009) defines litter as any misplaced solid waste. Roadside litter, in par-

ticular, mostly consists of the items that are discarded by motorists, bicyclists and pedestrians on roadways; Cigarette butts, drink containers, plastic bags, napkins, and fast-food packaging might be some of the most familiar ones to our eyes. Illegal dumping is another form of misplaced waste which is often differentiated from littering, particularly, in terms of its behavioral aspect. Environmental Protection Agency (EPA) (1998) defines illegal dumping as "primarily non-hazardous materials that are dumped to avoid either disposal fees or the time and effort required for proper disposal". Illegal dumping commonly consists of larger items such as construction debris, furniture, and mattresses. Both littering and illegal dumping make our roads visually unpleasant, but their negative impacts go far beyond the aesthetic issues and include various environmental, social, and economic issues. More importantly, any external object from littering or illegal dumping that ends up on the roads can pose safety hazards for motorists and cause operational issues (Forbes, 2004; GAO, 2012).

Litter can have detrimental impacts on the environment. While sitting on the roadside, leftover foods discarded can be an attraction for animals and increases their chance of being killed in a vehicle-animal collision (Forbes, 2009). However, wind and rain are two major factors that can spread the impact of roadside litter far beyond roadway boundaries. Major environmental concerns caused by roadside litter include water pollution, soil pollution, and impacts on animal life. Lighter-weight material such as cigarette butts can be washed away with the rain or blown by the wind and end up in waterways and streams and even find their way into lakes, rivers, and oceans. The toxic chemical content of cigarette butts and microplastics in marine environments can be consumed by freshwater fish and other marine creatures and eventually appear in our food (Gregory, 2009; Slaughter et al., 2011; Thiele, Hudson, Russell, Saluveer, & Sidaoui-Haddad, 2021). Another unfortunate environmental impact of litter is harming wildlife. Various species of animals in land and water suffer from ingesting litter or being entangled and smothered by discarded products (Gregory, 2009). It is reported that over 1 million seabirds and 100,000 marine mammals including dolphins and whales are killed by plastic litter (Department of Biodiversity, Conservation, and Attractions, 2015).

A staggering amount of money should be spent each year for the collection and removal of litter. Keep America Beautiful (KAB) national study (Stein, 2009) estimated the annual cost of litter removal (including roadside and other types of litter) in the U.S. to be $11.5 billion. It's a significant amount of money that is imposed on the federal and local governments, businesses, educational institutions, and volunteer organizations. Nelson (2001) surveyed 26 states' Departments of Transportation (DOTs) in 1999 and estimated that they spent nearly $120 million on litter cleanup. In addition to the direct costs of collection and disposal, many businesses and individuals can get impacted by the indirect cost of litter. This can include the potential decrease in property value and the profit loss for businesses due to the diminished number of customers as a result of lit-

ter in the area (Forbes, 2009).

Roadside litter and illegal dumping can also cause safety hazards for road users and create operational issues for the transportation network. Larger solid objects, in particular, can be extremely dangerous on the roads and can directly hit a vehicle or indirectly cause a collision (Forbes, 2004). However, smaller items can be hazardous as well. Discarded cigarette butts are known to be a cause of bush fires along the roads, but they can even put other vehicles on fire. In the incident of the Mont Blanc Tunnel fire in 1999, a cigarette butt caused a fire which resulted in 39 deaths, $1 million economic loss, and the tunnel being out of operation for 3 years. Further, the safety impact of roadside litter is not limited to motor vehicles and can also affect bicycle and scooter riders. Smaller objects including broken glasses usually end up on the side of the roads and pose safety hazards on bike and scooter riders who use that portion of the road as their designated path. These groups are considered vulnerable users who are at a higher risk of injuries and fatality in a collision.

In addition to the motorists and pedestrians, the KAB national study (Stein, 2009) considers other sources where litter can originate from; Dumpsters and trash cans that are improperly covered, construction sites with no traps and receptacles, vehicles with unsecured loads, and household waste that get scattered before collection. Forbes (2004) introduces a separate category for litter that originates from vehicles. By his definition, Vehicle-Related Road Debris (VRRD) is defined as "vehicle parts or cargo that has been unintentionally discharged from a vehicle onto the roadway". Vehicle parts usually end up on the road due to collisions or wear and tear.

Researchers who studied littering behavior classify litter in two main categories of deliberate and negligent. Deliberate (also known as "intentional") littering occurs when a person discards waste materials with a notable intention by throwing, flicking, dropping, dumping, or similar acts (Beck, 2007). On the other hand, negligent littering (also known as "accidental" and "non-deliberate") happens when waste materials end up in an incorrect location with no direct intention. Based on this definition, the litter originating from uncovered dumpsters, unsecured loads, and other vehicle-related debris are considered negligent. Motorists and pedestrians, however, can be associated with either group.

Delaware struggles with an ongoing litter problem. During 2016, Adopt-A-Highway session, volunteers picked up about 2000 of the nearly 32,000 bags of trash collected along Delaware's roads (State of Delaware News, 2017). In 2016, in an annual event held by Imagine a Litter-Free Delaware Day, more than 400 volunteers picked up 3500 bags of food wrappers and other garbage during the event, enough to fill 17 school buses (The News Journal, 2016). The crisis of roadside litter stems partly from the rising of the vehicle-miles traveled (VMT) on one hand, and the consequences of consumerism, on the other. A typical person in our era consumes more products than any other time in the past, which increases the number of items that can be potentially littered. Moreover,

the emergence of the global pandemic due to the COVID-19 in 2020 has intensified the litter problem. The use of Personal Protective Equipment (PPE) and cleaning products such as face-covering masks, latex gloves, and wiping pads increased drastically during the pandemic. It was estimated that every month, 129 billion face masks and 65 billion gloves were used globally during the COVID-19 pandemic (Prata, Silva, Walker, Duarte, & Rocha-Santos, 2020). Moreover, the demand and use of single-use plastic for packaging and other purposes surged remarkably during the pandemic (Patrício Silva et al., 2021).

The existing publications that address the issue of litter in Delaware are scattered and might be confusing for those who need to get familiarized with different aspects of this problem. This study focuses on the issue of roadside litter in Delaware and attempts to put forth a better understanding of the extent of the issue, the current efforts for litter abatement, and introduces possible ideas for mitigating this problem more effectively. For this purpose, a collection of documents, including academic and non-academic literature, have been reviewed and summarized.

2. Characteristics of Litter in Delaware (2018 Statewide Survey)

Delaware was excluded from Beck (2007) national study, and no accurate data was available to determine the extent of the litter problem in the state until very recently. In 2018, Keep Delaware Beautiful (KDB), in consultation with the Delaware Solid Waste Authority (DSWA) and the Delaware Department of Transportation (DelDOT), responded to the need for assessment of the current situation of the roadside litter and conducted a statewide survey. The survey was conducted by DSM Environmental Services, Inc. (DSM) and MSW Consultants as contractor and sub-contractor, respectively. For comparison purposes, this survey was conducted based on the same methodology used by the 2008 KAB national study (Stein, 2009). In addition to examining the amount and composition of roadside litter, this survey evaluated a hypothesis that claimed single-stream recyclables collected by haulers have contributed to the problem.

To examine the composition of the litter, 60 road segments were randomly selected throughout the US and state highways. Additionally, 20 segments were chosen from those roads that were leading to the Delaware Solid Waste Authority (DSWA) Transfer Stations. Of the main 60 survey sites, 2 were located on interstates, 28 on US routes, and 30 on state routes. Similar to many other litter surveys, the collected litter was divided into two groups of large and small litter. Large litter includes those greater than 4 inches in size. The study doesn't mention any minimum length for the smaller group.

The composition of litter that is reported for each group is shown in **Figure 1**. For the smaller group, tobacco and plastic products can be identified as two main categories, accounting for 37% and 32% respectively. On the other hand, for the larger group, plastic is the dominant category that comprises almost half

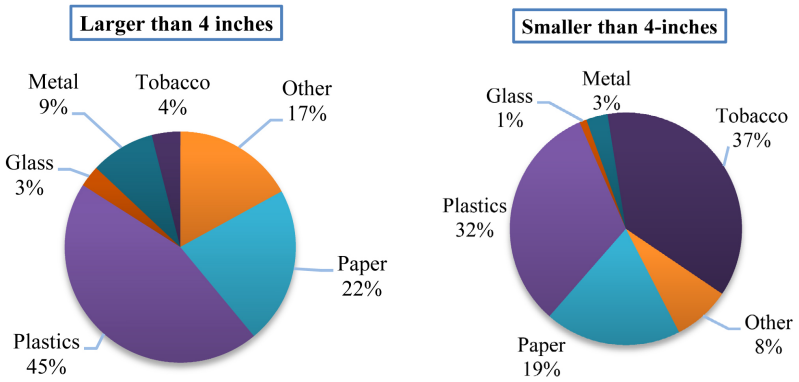

Figure 1. Composition of litter by material in Delaware (DSM Environmental & MSW Consultants, 2018).

of the litter. Paper accounts for nearly one-fifth of each group, and the share of metal and glass materials seems relatively insignificant. On average, this survey found 1120 items per mile for the large litter and 4967 items per mile for the small litter. Further, the result didn't show any significant difference between the amount of litter on the roads leading to the Delaware Solid Waste Authority and other roads. Therefore, the hypothesis that the single-stream recycling collection has led to littering the roads was rejected.

Figure 2 shows the average number of items per mile for the Delaware statewide rate as well as for each county. Comparing the numbers from the national survey and Delaware shows that the rate of large litter in Delaware is almost twice as much as the national average. The study claims that this significant difference is mostly due to the time difference between the two studies and is related to the fact that the use of plastic products has significantly grown over these nine years. On the other hand, the rate of litter smaller than 4 inches in Delaware is nearly 26% lower than the 2009 national average. The average rate of litter is also reported for each road function class. As shown in **Figure 3**, Interstates are the most littered road type for both large and small groups, followed by U.S. Highways and State Roads respectively. The total number of items on U.S. Highways is nearly 2.5 times the rate for State Roads, and on Interstates nearly 3.5 times the rate for U.S. Highways.

Comparing the result of this survey with several litter surveys in other states might not be very accurate because of utilizing various methods for counting the litter and reporting the results. However, a very recent litter survey in Pennsylvania (Burns & McDonnell, 2020) used a similar method as the one in Delaware and can be used for a side-by-side comparison. **Figure 4** and **Figure 5** show the percentage of litter by material type for both large and small groups in Delaware and Pennsylvania. It appears that the distribution of litter is very similar for the two states. Particularly, the identical share of plastic in large litter groups implies that the increased rate of plastic litter compared to the national KAB study in 2008 is not exclusive to Delaware and is more likely to follow the trend of the increased uses of plastic over time. It should be mentioned that the Pennsylvania

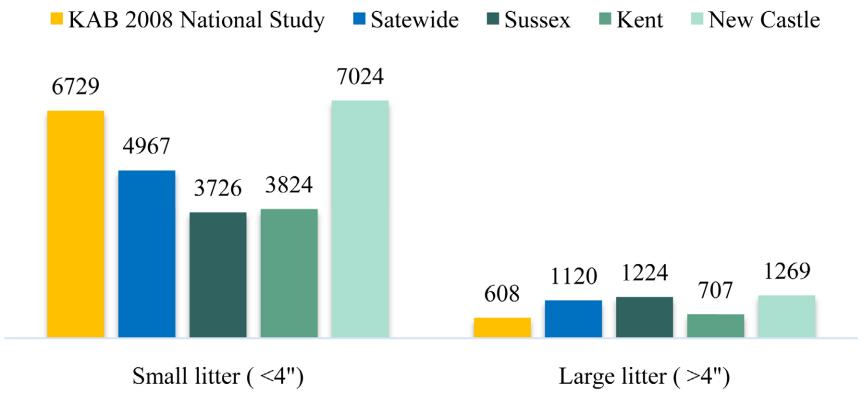

Figure 2. The number of litter items per mile at the county, state, and national level (DSM Environmental & MSW Consultants, 2018; Stein, 2009).

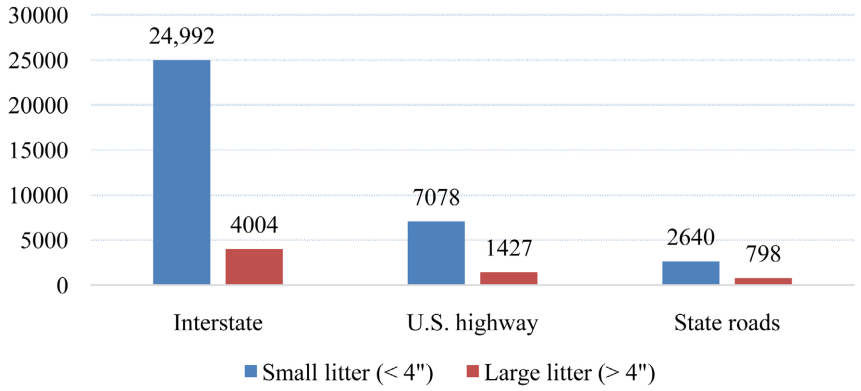

Figure 3. The number of litter items per mile by road function class (DSM Environmental & MSW Consultants, 2018).

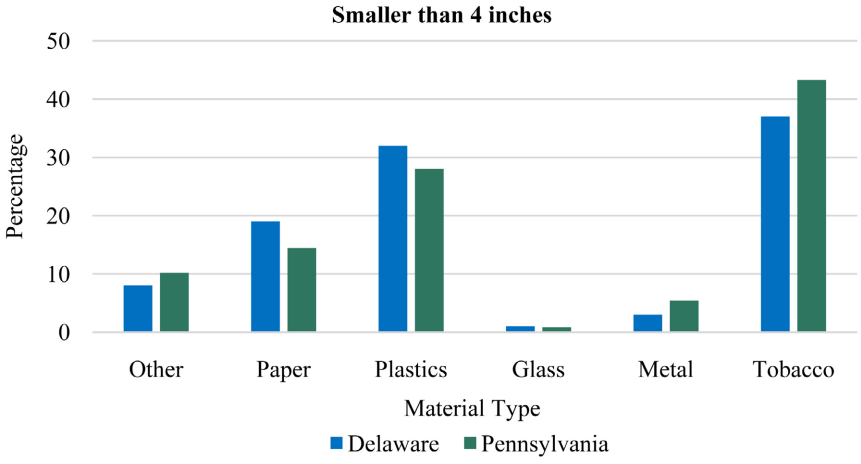

Figure 4. Small litter by material type in Delaware V.S. Pennsylvania (Burns & McDonnell, 2020; DSM Environmental & MSW Consultants, 2018).

survey also reported "Tire Treads" and "Organics" as two additional material categories, which in the charts below, the share of these categories are included in "Others" for a better comparison.

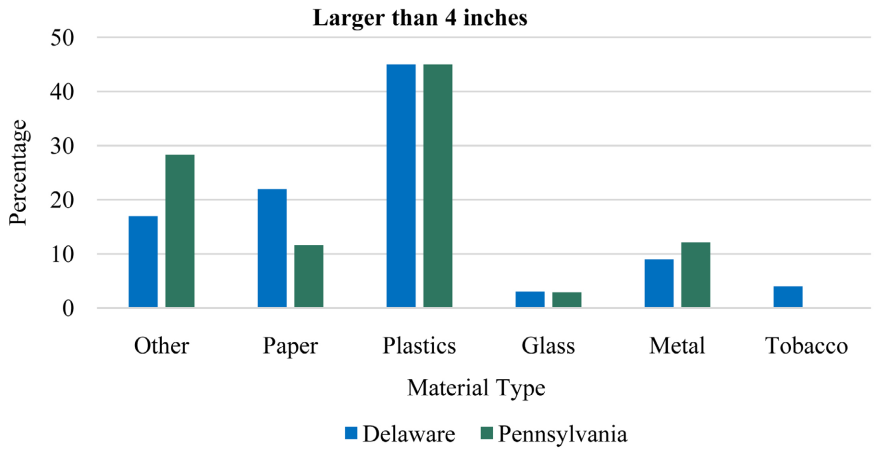

Figure 5. Large litter by material type in Delaware V.S. Pennsylvania (Burns & McDonnell, 2020; DSM Environmental & MSW Consultants, 2018).

3. Current Efforts in Delaware

The Delaware Department of Transportation (DelDOT) is the main organization that takes care of the roadside litter. However, volunteer programs and campaigns play an important role in reducing litter. DelDOT's Adopt-A-Highway (AAH) Program started in 1990 and currently has over 1000 members including individuals, groups, and organizations (DelDOT, 2018). DelDOT and AAH collect 35,000 bags worth of trash every year, along with 6000 tires and hundreds of appliances (The Daily Times, 2019). According to Jennifer Cohan, the Secretary of Transportation, DelDOT invests about $2 million on litter cleanup across the state annually (State of Delaware News, 2019). DelDOT had an additional $750,000 in its budget in 2020 for contractual trash pickup on Delaware roadways (The Daily Times, 2019).

Delaware Governor, John Carney, has addressed the issue of litter in Delaware and the illegal dumping problem, particularly in Sussex County (Cherry, 2020). In recent years several litter-free movements have been promoted including establishing the statewide anti-litter campaign "Keep Delaware Litter Free" in partnership with KDB. Another successful effort was launching the Work-a-Day Earn-a-Pay Program. This program was established first in the city of Wilmington and now has gone beyond. DelDOT in partnership with Goodwill of Delaware has invested $150,000 to administer this program and is planning on expanding this program. Since March 2019, cleanups were performed three times per week along the I-95 corridor in Wilmington and 759 bags of trash have been removed (State of Delaware News, 2019). While volunteers are mostly prohibited from work on high-risk locations such as interstates, usually contractors and DOTs maintenance crew do the cleanup on those locations which is more costly. Such a program can address this issue by lowering the cleanup cost for DelDOT as well as providing individuals with an opportunity to earn a wage.

Another recent progressive step for Delaware was revising some legislation that allows tackling the litter and illegal dumping problems more effectively.

Signing *House Bill 130* has banned the use of single-use plastic bags which aims to encourage the public to use reusable and recyclable bags. The 2018 survey showed that Plastic Bags and Films account for 17.3% of the total number of litters. Therefore, this bill is expected to have a positive impact on reducing this specific litter type in Delaware. *Senate Substitute 1 for Senate Bill 5* is another piece of legislation that focuses on increasing the penalties for those who commit illegal dumping and aims to improve the enforcement (WITN Channel 22 News, 2019).

According to Delaware's litter control law (Delaware Laws, 2021), "a person who is found guilty of littering or illegal dumping can be fined no less than $50 and given up to eight hours of community service for a first offense". That rises to a $75 fine and up to 25 hours of community service for a second offense within two years. If the offense occurred on or along a Delaware byway—defined as any road adjacent to an area of particular scenic, historical or cultural interest—an additional mandatory penalty of $500 must be imposed for every first, second, and subsequent offense, in addition to the fine. Concerning the litter originating from unsecured loads, Chapter 43 of Title 21 of the state law (Del. C. Title 21 § 4371) currently considers a fine between $10 to $28.75 for the first time and up to $100 for the subsequent offenses (The Delaware Code Online).

Regarding illegal dumping, the minimum penalty fee has increased to $500 and $1000 for the first and subsequent offenses respectively. However, illegal dumping can be challenging to fight back. Since only a few officers handle environmental crimes across the state, getting away with illegal dumping can be easy for the offenders (Smith, 2018). **Figure 6** shows some examples of illegal dumping in the Wilmington area that was caught on camera by the state police (Parra, 2017). Since 2013, the Delaware Department of Natural Resources and Environment (DNREC) law enforcement officers have only arrested 96 people for "Improper Disposal of Solid Waste" with the total fines of $50,000, which is only

Figure 6. Examples of illegal dumping in Wilmington (Parra, 2017).

a fraction of what it costs the state to clean up and properly dispose of this waste (Smith, 2018).

The current DelDOT smartphone application provides users with an option for reporting an issue, where they can report littering and debris on the road. Users are also able to provide pictures and other documents along with their reports. DNREC's Natural Resources Police Environmental Crimes Unit is also in charge of investigating the violations related to illegal dumping and provides a complaints line for phone calls. Although these methods can potentially be effective, the public doesn't seem to be well aware of them. Neither the number of downloads nor the review ratings seem promising for the DelDOT's app both on iPhone and Android platforms and improvements in this area seem necessary.

4. Conclusions and Recommendations

Many recent efforts have been undertaken by governmental and volunteer-based programs in Delaware to fight back the issues of litter and illegal dumping. However, despite the efforts, the pace at which people litter is much faster than DelDOT and volunteers can pick them up. The issue of litter is a complex problem that doesn't seem to have a single solution. A comprehensive strategy should be established for mitigating these problems that include various preventive and removal methods to satisfy both short-term and long-term goals. Litter removal is a very effective approach in the short term, but more fundamental preventive strategies are required to minimize these issues in the long run.

4.1. Education and Public Awareness

The public needs to be educated about litter and its safety, environmental, social, and economic consequences. Increasing the public's awareness about litter should be done at different levels and target various groups in the society. In addition to choosing the right content, the means for conveying the message is significantly important. While conventional methods such as advertising on TV, radio, and billboards can still be effective especially for older age groups, using social media not only can target younger age groups who are more likely to litter, but also it can remarkably increase the number of targeted audiences. The advertisements should include educational content, but also should warn people about the possible fines and penalties as well. Schultz (2009) warns about using the signs and messages that show a littered area or gives facts about the amount of existing litter. This study claims that these messages can even have a reverse impact by implying that many others do litter.

Unsecured loads and other types of vehicle-related debris are major sources of negligent litter that comprise a significant portion of the roadside litter. DelDOT, DMV, and other relevant organizations should focus more on educating drivers (particularly pickup truck drivers) on the proper methods for securing their loads and other maintenance tips to reduce the number of fallen vehicle parts and cargo on the roads.

4.2. Encouragement and Engagement

Encouraging and engaging more people and groups in volunteer works such as the AAH program not only will facilitate the cleanup process but also has proven to have the highest impact on people's commitment to anti-littering behavior (Torgler, García-Valiñas, & Macintyre, 2008). Encouraging different private and governmental agencies, educational institutions, and businesses to participate in anti-litter programs can be a potential approach to involve more people in such movements. Holding litter removal events can be endorsed as an opportunity both for social interactions and physical activities to gain more participants.

4.3. Law Enforcement

Although the current legislations criminalize littering and illegal dumping and has considered fines and other penalties for the offenders, the enforcement methods are not effective enough. The number of people that have been arrested and fined for these crimes is disproportionate to the number of those who commit them. Although littering and illegal dumping can happen in any location and it is challenging to catch the offenders, but more effective measures need to be established. For instance, certain locations are known to be suffering from littering and dumping more than others, and utilizing Closed-Circuit Television Cameras (CCTV) can be an effective way to identify the litterers and enforce the law (Forbes, 2009). Some developing technologies such as IntuVision (2021) are even able to monitor the video recordings and automatically identify larger objects that have been thrown out of a vehicle and report the incident.

Another approach for improving the enforcement measures is relying on other citizens' reports of littering and illegal dumping. Although there are already some established methods that allow people to report such incidents, they don't seem to be very effective. First, the existing methods should be improved in order to make the process as easy as possible. Second, they should be well advertised as part of the education and public awareness programs so a significant portion of the people will be aware of these methods.

4.4. Improving Waste Receptacles

The number of receptacles, their location, and their design can directly affect the amount of litter. Studies have shown that a persuasive design of receptacles can lead up to a 50% reduction in littering behavior (de Kort, McCalley, & Midden, 2008). The KAB behavioral survey (Schultz, 2009) observed that the average distance of individuals who littered from the closest receptacle was 29 feet and concluded that the availability of receptacles to be a factor that significantly affects littering. People's need for immediate access to a receptacle in the case of disposing of PPE and other COVID-19 related waste can be much more crucial. While individuals might be willing to hold on to a non-bio waste item until reaching a trash can, they are less likely to do so for PPE due to the concerns about the contagiousness of the disease.

Figure 7. An example of a suggested ballet bin for Delaware—Original picture from (Ballot Bin, 2021).

The impact of receptacle availability is particularly important for cigarette butts. Holding to a lit cigarette is notably more difficult than other typical types of litter such as a snack wrapper and access to an ash receptacle can play a major role in an individual's decision on where to disposing of their cigarette butt. Schultz's (2009) observations throughout the U.S. showed that the availability of ash receptacles doesn't meet the need of smokers who have been pushed to smoke in outdoor areas due to the recent policies of banning indoor smoking. An innovative idea for reducing cigarette butts was introduced by Ballot Bin (2021). As shown in **Figure 7** these bins encourage smokers to discard their cigarette butts in the bins as a way to vote for a fun fact such as sport teams' rivalries.

Other important design aspects for receptacles are having sufficient capacity and being covered. It is common to see trash cans and dumpsters that are full and overflowed trash materials have piled up around them. In these cases, either higher capacity receptacles should be provided, or the trash collection should be done more frequently. Receptacles should also be covered and designed in a way to prevent their content from being blown by the wind and scattered around.

The main goal of this study was to present a concise yet comprehensive information about the extent of the issue of roadway litter and the current abatement efforts in the state of Delaware and to introduce suggestions for mitigating the problem. This was accomplished by comprehensively reviewing the most important documents at the national level and a few examples from different states including the state of Delaware. As the governments and public knowledge about the serious safety, environmental, social and economic ramifications of this complex issue increases, more publications with more precise and detailed

data and useful information will appear in the literature. It is the hope of the authors that future studies document the data and statistical analysis related to many of the mitigation strategies reported in this article so comprehensive studies can be conducted on the cost/benefit of the most useful methods and strategies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Ballot Bin (2021, January 10). *Keep Streets Butt-Free with the Ballot Bin.* https://ballotbin.co.uk/

Beck, R. W. (2007). *A Review of Litter Studies, Attitude Surveys and Other Litter-Related Literature.* Keep America Beautiful.

Burns & McDonnell (2020, January). *Pennsylvania Litter Research Study*. Keep America Beautiful, Burns & McDonnell Engineering Company, Inc. https://files.dep.state.pa.us/waste/Bureau%20of%20Waste%20Management/WasteMgtPortal-Files/Littering/Pennsylvania%20Litter%20Research%20Study%20Final%20Report%201.30.2020.pdf

Cherry, A. (2020, January 23). *'Take Responsibility': Delaware Launches 'Keep DE Litter Free' Campaign*. https://www.wdel.com/news/take-responsibility-delaware-launches-keep-de-litter-free-campaign/article_f44b4d76-6c31-11e9-a208-53c252a3cb77.html

de Kort, Y. A. W., McCalley, L. T., & Midden, C. J. H. (2008). Persuasive Trash Cans. *Environment and Behavior*, *40*, 870-891. https://doi.org/10.1177/0013916507311035

Delaware Laws (2021, January 10). *Title 16—Chapter 16. Litter Control Law*. https://delcode.delaware.gov/title16/c016/index.shtml

DelDOT (2018). *Adopt-A-Highway Program*. https://deldot.gov/Programs/adopt/adopt_a_hwy/index.shtml?dc=stats

Department of Biodiversity, Conservation, and Attractions (2015). *Marine Park Protectors*. https://www.dpaw.wa.gov.au/management/marine/marine-parks-wa/398-marine-park-protectors?showall=1

DSM Environmental & MSW Consultants (2018). *State of Delaware Baseline Statewide Visual Litter Study.* Keep Delaware Beautiful.

Environmental Protection Agency (1998). *EPA Illegal Dumping Prevention Guidebook* (EPA 905-B-97-001). Environmental Protection Agency.

Forbes, G. J. (2004, June). *The Safety Impact of Vehicle-Related Road Debris*. AAA Foundation for Traffic Safety.

Forbes, G. J. (2009). *Reducing Litter on Roadsides* (NCHRP Synthesis: Vol. 394). Transportation Research Board. http://nap.edu/14250

GAO (U.S. Government Accountability Office) (2012, November). *Highway Safety: Federal and State Efforts Related to Accidents That Involve Non-Commercial Vehicles Carrying Unsecured Loads: Report to Congressional Committees*.

https://www.gao.gov/products/gao-13-24

Gregory, M. R. (2009). Environmental Implications of Plastic Debris in Marine Settings—Entanglement, Ingestion, Smothering, Hangers-on, Hitch-Hiking and Alien Invasions. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences, 364,* 2013-2025.

IntuVision (2021, May 3). *Intuitive Video Analytics*. https://www.intuvisiontech.com

Nelson, D. C. (2001). *Roadside Litter Control: A Survey of Programs and Practice*. Maryland State Highway Administration. http://www.roads.maryland.gov/opr_research/md-01-sp707b4i-roadside-litter-control_a-survey-of-programs-and-practice-report.pdf

Parra, E. (2017, June 1). Frustrated by What He Saw, Police Officer Cleaning up Wilmington. *The News Journal*. https://www.delawareonline.com/story/news/local/2017/06/01/wilmington-delaware-police-officer-cleaning-up-city/340822001/

Patrício Silva, A. L., Prata, J. C., Walker, T. R., Duarte, A. C., Ouyang, W., Barcelò, D., & Rocha-Santos, T. (2021). Increased Plastic Pollution Due to COVID-19 Pandemic: Challenges and Recommendations. *Chemical Engineering Journal, 405,* Article ID: 126683. https://doi.org/10.1016/j.cej.2020.126683

Prata, J. C., Silva, A. L. P., Walker, T. R., Duarte, A. C., & Rocha-Santos, T. (2020). Covid-19 Pandemic Repercussions on the Use and Management of Plastics. *Environmental Science & Technology, 54,* 7760-7765. https://doi.org/10.1021/acs.est.0c02178

Schultz, W. (2009). *Littering Behavior in America Results of a National Study*. Keep America Beautiful, Inc. https://kab.org/wp-content/uploads/2019/10/NewsInfo_Research_LitteringBehaviorinAmerica_2009Report_Final.pdf

Slaughter, E., Gersberg, R. M., Watanabe, K., Rudolph, J., Stransky, C., & Novotny, T. E. (2011). Toxicity of Cigarette Butts, and Their Chemical Components, to Marine and Freshwater Fish. *Tobacco Control, 20,* i25-i29. https://doi.org/10.1136/tc.2010.040170

Smith, J. (2018). Delaware Stepping up Efforts to Prosecute Those Dumping Trash along Roadways. https://www.delawareonline.com/story/news/2018/04/08/delaware-stepping-up-efforts-prosecute-those-dumping-trash-along-roadways/487583002/

State of Delaware News (2017, October 2). Imagine a Litter-Free Delaware Clean up Scheduled. *State of Delaware News*. https://news.delaware.gov/2017/10/02/imagine-a-litter-free-delaware-scheduled/

State of Delaware News (2019, July 18). Governor Carney Announces Expansion of DelDOT's Work-a-Day Earn-a-Pay Program. *State of Delaware News*. https://news.delaware.gov/2019/07/18/governor-carney-announces-expansion-of-deldots-work-a-day-earn-a-pay-program/

Stein, S. R. (2009, September). *2008 National Visible Litter Survey and Litter Cost Research Study* (No. 20878). Keep America Beautiful.

The Daily Times (2019, May 1). Delaware, Stop Dumping: Gov. John Carney Launches Statewide Anti-Littering Campaign. *The Daily Times*. https://www.delmarvanow.com/story/news/2019/05/01/delaware-stop-dumping-governor-launches-anti-littering-campaign/3631217002/

The News Journal (2016). *DelDOT: Road Litter Still a Problem*.

Thiele, C. J., Hudson, M. D., Russell, A. E., Saluveer, M., & Sidaoui-Haddad, G. (2021). Microplastics in Fish and Fishmeal: An Emerging Environmental Challenge? *Scientific*

Reports, 11, Article No. 2045. https://doi.org/10.1038/s41598-021-81499-8

Torgler, B., García-Valiñas, M. A., & Macintyre, A. (2008). *Justifiability of Littering: An Empirical Investigation* (Working Paper No. 59). Fondazione Eni Enrico Mattei. https://doi.org/10.2139/ssrn.1165203 http://hdl.handle.net/10419/53274

WITN Channel 22 News (2019, July 30). Governor Carney Signs Legislation to Ban Plastic Bags, Reduce Litter in Delaware. *WITN Channel 22 News*. https://www.witn22.org/2019/07/30/governor-carney-signs-legislation-to-ban-plastic-bags-reduce-litter-in-delaware/