Litter on Delaware Highways

By

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Executive Summary

Many concerns have been raised over the past several years regarding a significant increase in the amount of litter and illegal dumping along Delaware roads. Growth of the population, increase in vehicle-miles-traveled, and consumption of more products are factors that have contributed to aggravating this problem. Moreover, the global pandemic due to COVID-19 has raised a new issue as an enormous number of masks and gloves are now ending up as litter. The aesthetic issue is the most obvious impact of litter, but litter can also interrupt the flow of traffic and cause delays, or even pose safety hazards on the road that can lead to a crash. Moreover, litter pollutes the environment, causes fires, harms wildlife, and puts public health in danger. Removing and disposing of litter is very costly and imposes about $2 million only on DelDOT each year. Despite many efforts by governmental agencies and volunteer organizations, litter is an ongoing problem. This study conducts a literature review to provide a better understanding of different aspects of this problem and finding the best practices for mitigating the issue in the state of Delaware based on other national and international experiences.

Studies that have focused on the behavioral aspect of the problem, claimed that lack of ownership is one of the main reasons that many people litter. In terms of the characteristics of litterers, men were found to be more likely to litter than women. Also, teenagers and young adults commit littering more than those in older age groups. Identifying the group of people who are more prone to littering can be helpful for establishing more effective anti-litter strategies.

Multiple surveys in the US found out tobacco products, plastic, and paper comprise the majority of the litter composition. The Keep Delaware Beautiful survey in
2018 showed that plastic accounts for 45% of litter larger than four inches. Tobacco products and mainly cigarette butts, was the most common item smaller than 4 inches, accounting for 37% of this category. Although the overall rate of litter (items per mile), was lower than the national average, the rate of large litter was nearly twice as high. New Castle County was found to be the most littered of the three Delaware counties. Interstates had the highest litter rate, followed by U.S. Highways, and State Roads, which is expected with regards to their traffic volume.

At the end of the report, a set of recommendations is presented that can potentially reduce the rate of roadside litter. The most fundamental approach is prevention, which can be achieved through education, prompting, public awareness, consequence control, and designing proper disposal facilities. The removal process also needs the maximum participation of businesses, organizations, campaigns, and individuals. Using various forms of advertisement through billboards, posters, radio, TV, and social media can be an effective way to spread anti-litter messages and engage more people in the anti-litter movements.
Chapter 1

INTRODUCTION
1.1 Background

The term litter generally refers to any misplaced solid waste [1]. Fast food packages, drink containers, plastic bags, shredded tires, and many other pieces of litter are some of the common items sitting along the roadways. Illegal dumping is another form of misplaced solid waste that is distinguished from litter by most sources, albeit some have treated the two categories as one [2]. Environmental Protection Agency (EPA) [3] defines illegal dumping (also known as “fly dumping”, “open dumping”, and “midnight dumping”) as “primarily non-hazardous materials that are dumped to avoid either disposal fees or the time and effort required for proper disposal”. Based on these definitions, the intention of the person at fault seems to determine whether a misplaced waste is considered as litter or illegal dumping. However, there is usually a significant difference between the two groups in terms of the material type. Illegal dumping usually consists of larger items such as construction debris, furniture, and mattresses, while litter mostly consists of smaller items thrown out by vehicle occupants and pedestrians. From a transportation standpoint, litter and illegal dumping can both cause safety and operational issues as well as making our roads visually unpleasant. Further, they associate with various, social, economic, and environmental issues.

The crisis of roadside litter is growing in many parts of the United States (U.S.) as the number of vehicle-miles traveled (VMT) is increasing on the one hand, and on the other hand, a typical person in our era consumes more products than any other time in the past. Moreover, the emergence of the global pandemic due to the COVID-19 in 2020 has intensified the litter problem as the use of gloves, masks, and other personal protection equipment drastically increased, and many ended up as litter on roadways. The extent of the issues caused by litter on roadways goes far beyond aesthetics and can
cause transportation-related issues as well as other social, economic, and environmental impacts.

From a transportation point of view, litter can cause safety and operational issues for road users. Larger items in particular that originate from illegal dumping or unsecured loads can interrupt the traffic flow and cause delay by slowing down the vehicles that try to avoid hitting those objects. More importantly, these items can directly or indirectly cause crashes. Debris-related crashes are reported to constitute 0.1 percent to 0.5 percent of all crashes [4]. Furthermore, every time a clean-up crew or volunteer attempts to remove litter from roadsides they are exposed to some level of risk of road accidents.

Litter is costly to be removed. Federal and local governments, businesses, volunteer organizations, and individuals in the U.S. spend nearly $11.5 billion each year for removing litter according to a 2008 national study [5]. Such a budget could be spent on more essential needs if no one would litter in the first place. Moreover, there is an indirect cost associated with roadside litter when a littered area will experience a decrease in property value or businesses face economic loss because of diminished interest of the public in visiting the area. Socially, there is a correlation between the increase of litter in an area and the level of people’s sense of well-being and crime [2]. A littered area is also less prone to be visited by the public and therefore businesses have a lower chance to thrive.

Litter can harm the environment in many ways. It takes weeks to even hundreds of years for different types of litter to be decomposed in nature. Lighter litter items can be blown by the wind and end up in waterways and even find their way to the ocean, polluting the water and harming marine life. An animal being trapped or hurt by a piece
of plastic and other types of litter is an unfortunate scene that is a result of human misbehavior. Leftover foods alongside the roads can attract animals and increase the risk of them being killed in an accident. Cigarette butt is one of the most common type of litter that not only can cause fires but also contains toxic materials that can be washed away with rains and contaminate the soil and the groundwater.

The emergence of the global pandemic due to the COVID-19 in 2020, was an unprecedented event that caught the world unprepared in various aspects. Properly disposing of a myriad of protection and cleaning products such as face masks, latex gloves, and wiping pads was one of them. The sudden increase in production and consumption of protection and cleaning products on one hand, and people’s urge for immediate disposal of those items, on the other hand, led to a situation that such products can be seen on the roadsides more than ever before. Another major concern raised by the COVID-19 is the health of the litter removal crew and volunteers against the disease while being in touch with numerous items that might be contaminated.

The state of Delaware struggles with roadside litter and illegal dumping as well. In 2017, DelDOT crews, volunteer groups from the Adopt-A-Highway (AAH) program, and many inmates from the Delaware Department of Corrections picked up 58,000 bags of trash and 6,000 tires along Delaware’s highways [6, 7]. Many efforts have been undertaken to fight this issue, including forming organizations, campaigns, volunteer works, educational programs, and law enforcement. Keep Delaware Beautiful (KDB) was established in 2016 in response to the litter problem in the state [8]. John Carney, Delaware’s governor, has addressed the issue in multiple speeches and launched a statewide anti-litter campaign “Keep DE Litter Free” in partnership with Keep Delaware Beautiful to encourage Delawareans and visitors to not litter. Yet, too much litter is
left on Delaware roadways and a comprehensive approach is needed for mitigating this ongoing problem.

### 1.2 Problem Statement

DelDOT has utilized volunteer individuals and businesses to help with programs such as Adopt a Highway, Sponsor a Highway, and Imagine a Litter-Free Delaware. DelDOT is investing nearly $2 million toward litter cleanup across the state [9]. Despite all the efforts, these programs no longer seem to adequately respond to the issue of litter on the roadways in Delaware. The litter problem is even aggravated in some aspects with the growth of the population, the increase in VMT, and issues related to the COVID-19 pandemic which implies a comprehensive study needs to be undertaken to address all the issues surrounding the problem of litter on Delaware roadways.

### 1.3 Motivation

Various aspects make this topic compelling. Delaware roadways suffer from the issues associated with roadside litter including social, economic, and environmental impacts. From a transportation point of view, litter can impose hazards for motorists and cause collisions as well as interrupting the traffic flow and causing delay. Economically, litter is very costly to remove. Roadside litter needs to be collected, transported, and disposed of properly. The litter removal process is slow because litter comes in various forms and sizes. There is not a single piece of equipment that can remove all the litter from roadways and most of the items need to be picked individually. Environmentally, litter can pollute the air, soil, and waterways, cause fire, and threaten wildlife. In conclusion, a litter-free road is more beautiful, safer for the road users, more
sustainable, cost less to be maintained, benefits public health, and helps the businesses to thrive.

1.4 Purpose and Objectives

A comprehensive research study needs to be undertaken to address many of the issues surrounding the frequency, type, source, and amount of litter on roadways. A comprehensive literature search needs to be conducted to see how other states and local transportation agencies deal with the problem of litter on their roadways. A comprehensive search of the literature is also needed to see if there are any federal, academic, and non-academic publications available regarding this problem. The aesthetic, operational, as well as safety of the driving public, needs to be studied. The public health problem arising from throwing food and other perishable items on roadways need to be looked at. The safety of the volunteers and the drivers during the events such as Adopt-A-Highway Program and Imagine Litter-Free Delaware need to be studied. Different states in the U.S. have utilized different strategies for mitigation of the issue of litter. This report attempts to conduct a comprehensive literature review to identify:

- The behavioral aspect of littering and characteristics of litterers;
- The characteristics of litter such as type, amount, source, and critical locations;
- The safety and operational impact of litter on transportation network;
- The economic and environmental impacts of litter;
- Different litter abatement strategies and recommending those that showed to be more successful and can be applied to the state of Delaware.
1.5 Abbreviations

DOT – Department of Transportation
KAB – Keep America Beautiful
KDB – Keep Delaware Beautiful
EPA – Environmental Protection Agency
IAR – Institution for Applied Research
VMT – Vehicle-Miles Traveled

1.6 Target Audience

This report is aimed to serve agencies, organizations, researchers, and any individuals who are interested in this topic. In particular, DOT, EPA, and policy and law-makers, and volunteer-based organizations need to be informed about the cause and extent of this issue and possible strategies for alleviating it.

1.7 Organization of the Report

In the present chapter a background of the literature, statement of the problem, and purpose of the study were presented. The following chapter (chapter 2-Literature Review) first tries to find an explanation for why people litter in the first place by reviewing the behavioral studies. Next, the characteristics of the roadside litter are discussed by looking at several surveys that identify the amount, type, location, and source of the items found on the roadside. Further, the safety and operational impact of litter on roadways are discussed from a transportation point of view. And lastly, some different abatement strategies including prevention and control programs are presented.
The third chapter is dedicated to the issue of litter and illegal dumping in Delaware. The characteristics of the litter such as type, location, and composition of the litter are discussed based on the 2018 KDB survey. Next, we talk about the current efforts for mitigating the problem, including the prevention campaigns, as well as litter removal programs by the Department of Transportation and volunteer programs. We talk about the consequence control and litter control laws in Delaware. Finally, in the last chapter, a summary and conclusion of the report are presented and based on the conclusion, some recommendations are presented that can potentially help to reduce the roadside litter issue in Delaware.
This chapter will present a review of the literature related to the problem of litter on roadways. The main reviewed works of literature were chosen from the studies done in the U.S., however, some of the relevant international studies were included as well. This chapter first tries to find an explanation for why people litter in the first place by reviewing the behavioral studies. Next, the characteristics of the roadside litter are discussed by looking at several surveys that identified the amount, type, location, and source of the items found on the roadside. Further, the safety and operational impact of litter on roadways are discussed from a transportation point of view. And lastly, some different abatement strategies including prevention and control programs are presented.

2.1 Littering Behavior

In order to understand people’s attitude towards littering some important questions that need to be asked are “who litters?” and “why they litter?” Littering is considered a social problem caused by the misbehavior of individuals whether it occurs intentionally or accidentally [10]. Surveys in the U.S. have shown that the majority of people are aware of littering as a problem, yet, many of them litter. In a 2006 survey in Georgia, 97% of the participants agreed that litter hurts the state's environment [11]. Findings of five litter behavior surveys from 1968 to 2006 show that despite the fact that most people know litter is a problem, about 40-50 percent of the participants admitted that they have littered in the past [12]. A more recent attitude survey in Pennsylvania reveals that over 90 percent of the responders believed that litter is a problem in the commonwealth [13].
2.1.1 Who litters?

An important part of the behavioral aspect of litter is identifying the characteristics of people who are more prone to littering. This can be a helpful step for establishing more effective prevention and control programs. Often, different preventive slogans and strategies need to be chosen to target different age groups and genders. There are a few surveys that have tried to identify the characteristics of litterers such as gender and age. The early study of Keep America Beautiful (KAB) 1968, revealed that males litter twice as much as females [1]. However, Schultz’s observations [10] contradicted any significant littering behavioral difference among genders.

Forbes [1] claimed that adults younger than 35, are twice more likely to litter than the age group of 35-49, and three times than the age group of 50 plus. Figure 2-1 presented by a survey in Georgia [11], which shows consistent results with other studies regarding the trend of age and gender of the litterers. Based on this study, males in the age group of 18-30 have the highest risk of littering. Another study in Georgia [14], extended their subject age group and included those younger than 18. Figure 2-2 shows the result of this study, which indicates the deliberate littering among teenagers between 11 to 17 is also very high, yet the 18-24 group has the highest rate. The difference between deliberate and negligent litter is explained in the next section.
Figure 2-1. Littering behavior of Georgians 18 and over by age and gender [11].

Figure 2-2. Littering by age groups and type [14].
The result of eight surveys that were conducted in different states of the U.S. between 1968 and 2006 are presented in Beck (2007) [12]. Although the method and questions of these surveys were not entirely the same, the main concepts were similar. Five out of seven studies identified males to be more prone to litter than females, and two studies didn’t realize a significant difference. The majority of the reviewed papers also identified age as an effective factor in littering behaviors. The possibility of littering is higher among young people and will decrease by age. This trend was also reported by KAB [10].

2.1.2 Why Do People Litter?

Various reasons could be behind the littering behavior, multiple surveys asked people "why do people litter?" and the most common responses included carelessness, laziness, lack of trash cans availability, and inadequate enforcement [12]. The KAB claims lack of ownership as one of the main reasons that cause people not to consider themselves responsible for cleaning the public environment and believing that someone else will clean up after them [5].

2.1.3 Negligent vs. Deliberate Littering

Littering behavior is usually considered to be either negligent or deliberate. Different studies have also used other terms such as “accidental”, “careless”, and “intentional”. Deliberate littering is defined as throwing, dropping, or discarding material or products in inappropriate locations intentionally [12]. Throwing out trashes from a vehicle and illegal dumping can be examples of this case. Negligent, accidental, or unintentional littering, on the other hand, happens when material or products end up
on the road with no direct intention. Vehicle debris from accidents or wear, material that falls from vehicle loads can be examples of this type. This category can also include items that spill from overloaded or tipped trashcans [12]. Determination of whether an item was deliberately littered or negligent can be difficult if the act of littering happened in the past. Beck [12] claims that based on the previous observations, some items such as snack wrappers, take-out food packaging, and beverage-related litter usually associate with deliberate littering, while newspapers, fliers, construction debris, and miscellaneous scraps have been usually linked to negligent littering.

Forbes [1] and Beck [12] both question using the term “accidental” since it may imply that the litterer was not at fault, instead suggesting using “negligent” litter since many of this litter type can be prevented by willful acts such as securing cargos. Forbes [1] reviewed the result of ten different states and compared the deliberate and unintentional littering (see Figure 2-3). He claims that the dominant type of littering in the U.S. has shifted from deliberate to negligent which might be as a result of the preventive programs. However, Schultz’s [10] observations of 9,757 individuals littering in 10 states revealed that 81% of littering was notably intentional through acts such as dropping, flick, and fling.

There are multiple factors that can affect negligent littering. The littering behavior of the same group of people might be different in various locations. Studies have unanimously reported that the presence of existing litter is a determining factor in people’s decision whether to litter or not. Individuals tend to adjust their behavior based on their perception of the norm of their surrounding environment [10]. The presence of even a few pieces of litter can imply the message that littering is acceptable in this area [2]. The theory of the "Broken Window" suggests that the presence of litter can convey
the “no consequences” message in that neighborhoods and even be linked to other crimes [15]. Another factor is the presence of receptacles. Schultz [10] reported that lack of receptacle availability accounts for up to 15% of the littering. This can be a much more crucial matter in the case of cigarette butt litter.

![Figure 2-3. Unintentional vs. Deliberate litter in different surveys [12].](image)

### 2.1.4 Surrounding Effects on Littering Behavior

There is a general consensus that littering in an area or society is greatly affected by perceived social norms [1]. The littering behavior of the same group of people might be different in different locations. The existing litter in an area might send a message that it is ok to litter here and there are no consequences, whereas a clean environment reflects a society that is intolerant of littering. The theory of the "Broken Window" suggests that a direct link between the presence of litter and the incidence of crime in
neighborhoods [15]. Even the presence of a few pieces of litter may make some people feel that there are no consequences and it is ok to litter in that place [2].

2.2 Litter Surveys

One of the primary goals of any litter surveys is to assess the amount, type, location, and source of the litter that already exists on the roadsides. This is a key step in establishing prevention and control strategies. The amount and type of litter can be affected by many factors such as the classification of the road, traffic volume, urban or rural area. Some of the reviewed studies only surveyed the visible litter, which is referred to the items larger than four inches in size, while some have also counted smaller pieces down to one inch. Lack of a uniform standard metric for reporting collected litter is an obstacle for a side-by-side comparison of the result of different studies and different prevention and controlling strategies [16][1]. For instance, some studies reported the amount of litter collected using weight (tons or pounds), while others used volume (cubic yards), area (acres), truckloads, and the number of trash bags. This makes for a difficult comparison among jurisdictions. In the following, the key characteristics of the litter are discussed based on the most relevant surveys.

2.2.1 Type and Amount

- Georgia 2006

Beck (2006) [14] conducted a visual litter survey in the state of Georgia at 96 sites and quantified the composition of litter. This report presented the result in twenty-two groups with respect to being either deliberate (ten groups) or negligent (twelve
groups). As is shown in Figure 2-4, miscellaneous plastic scraps and miscellaneous paper scraps comprised nearly 41% of the items found. Snack food packaging, vehicle debris, and packaging had the highest rate of negligent litter. Vehicle packaging was defined as the wrappers and discarded materials from automobile parts and servicing materials that are purchased at car parts shops and other stores. Cigarette butts did not meet the size threshold in this study yet they were counted separately in a smaller portion of each survey site. Approximately 42,912 cigarette butts were found which was eight times more than the total amount of other litter found on roadway edges.
Figure 2-4. Different types of litter in Georgia (2006) [14].
Beck (2007) [12] analyzed the result from nine litter surveys that utilized an IAR based methodology, including his 2006 Georgia survey, to attain the composition of litter for all nine states. The result is presented in Figure 2-5 which shows the composition of visible litter in eleven litter categories. Snack wrappers and food packaging comprised the largest percent of littered items by almost 13 percent. Miscellaneous paper and plastic each formed nearly 12% of all litter. On average these eleven categories of products comprise just nearly 88 percent of the total visible litter.

Figure 2-5. Pie chart of composition of the litter [12].
Keep America Beautiful (KAB) National Study 2009

The 2009 nationwide study by Keep America Beautiful (KAB) has gathered data from 240 locations from 45 states (Alaska, Delaware, Hawaii, New Hampshire, and Rhode Island were excluded). The locations were chosen randomly from both rural and urban areas and different types of roadways. This study estimates there are 51.2 billion pieces of litter on the roadways in the United States, 91% of which being less than four inches in size. The pie chart in Figure 2-6 shows the composition of the litter on the U.S. roadways in 2008 based on the number of items. Tobacco products including cigarette butts, cigars, chewing tobacco, and packaging are the most common items forming about 38% of all litter. Paper and plastic are in second and third place with near 20% each.

Figure 2-6. The material composition of the litter on U.S. roadways [5].
KAB also provided the top ten found litter items which are shown in Figure 2-7. Out of sixty-one categories of litter defined by this study, those top ten items account for near 80% of the total number. The cigarette butt is the most common item that can be found along the roadways followed by papers and plastic litter. As the figure implies, the share of cigarette butts is significantly higher than the rest of the items on the list.

![Bar Chart](image)

**Figure 2-7.** Top ten litter items in a mile of roadways in the U.S. [5].

KAB has also identified the most frequent types of litter based on a more specific product classification which is presented in Figure 2-8. Cigarette butts and other types of tobacco products comprised 38% of the total litter. Snack, fast food, other packaging, and container bottles account for 19.6% of all items. These seven product categories comprise 80% of all litter [5]. Product packaging is a common litter item on the roadways which comprises 18 percent of all litters and 41 percent of the litters 4 inches
and larger. Nearly two-thirds of the material used in the productions of these packaging is plastic [5]. For beverage containers, beer (30.5%), soft drinks (24.6%), and water bottles (5.9%) had the biggest share among the recognizable containers.

Figure 2-8. Litter type of interest [5].

- **Anacostia (2015)**

A litter survey was conducted in 2015 in the Anacostia Watershed, which encompassed certain portions of the District of Columbia (DC) as well as Montgomery and Prince George’s counties in Maryland. This document reported the components of litter in two groups of large (4 inches plus) and small (4 inches minus) litter from 84 roadway sites. The top three large items in the order of counts were sweet snack wrappers (7.9%), paper fast food napkins (6.9%), and miscellaneous paper (5.9%). For small litter, the top three items were glass (28.7%), cigarette butts (23.8%), paper scraps
(15.0%). This study also categorized each group by the material composition and the result is presented in Figure 2-9 and Figure 2-10. Plastic and paper form 73% of the all large litter group and for the small litter glass and tobacco with 57% are the two dominant materials.

Figure 2-9. Large litter on roadways by material [17].

Figure 2-10. Small litter on roadways by material [17].
This litter survey [18] was conducted in 2017 on 94 roadway sites throughout the state of New Jersey to identify the amount and composition of the litter. The methodology used in this survey was set to account for items one inch or larger so the result would be comparable to a former survey which was conducted in 2004 in the state. The result for the most common categories of litter is presented in Figure 2-11 which shows that the top five categories of litter were vehicle/construction-related items, paper, beverage containers, cups/lids/straws, and candy/snack packaging. Moreover, the top five components of litter most frequently found in New Jersey litter during this survey were Tire Scraps, Paper, Shrink Wrap, Sweet Snack Packaging, and Plastic Water Bottles as shown in Figure 2-11.

Figure 2-11. Most common litter categories [18].
Pennsylvania (2020)

A recent litter survey was conducted in 2018-2019 in Pennsylvania over 180 sites by Burns & McDonnell [13]. The study estimates over half a billion pieces of litter to exist on Pennsylvania roadways. This report breaks down the litter into six groups: Paper, plastic, glass, metal, organic, and others, each subdivided into more specific categories (85 in total). This survey found 186.2 million pieces of cigarette butt which forms 37.1 percent of the total litter and was the most frequent item. The next highest percentage belongs to plastic by 152.9 million (30.4 percent) pieces. Figure 2-13 presents the composition of litter items on roadways by the material group for all sizes of litter. 85.5% of litter in Pennsylvania were 4-inches or smaller in size; however, the more visible litter are those bigger than 4 inches which comprised 15.5% of the litter by count. Figure 2-14 and Figure 2-15 and, show the composition of litter for each group.
of small and large litter separately. Plastic composed the majority (45.0 percent) of larger litter while cigarette butts composed the majority (43.3 percent) of smaller litter [13].

Figure 2-13. Composition of the litter by count for all roadways [13].
Figure 2-14. Composition of litter by count for items less than 4 inches [13].

Figure 2-15. Composition of litter by count for items more than 4 inches [13].
### 2.2.2 Sources of Litter

A critical question about litter is finding the source. Although pedestrian and motorists are known to be the major sources of litter on the roads, there are not the only ones. The KAB national study [5] identifies seven major sources of litter as follow:

a) Pedestrians or cyclists  
b) Motorists  
c) Business dumpsters that are improperly covered (see Figure 2-16)  
d) Vehicles with uncovered loads (see Figure 2-17)  
e) Loading docks and commercial or recreational marinas with inadequate waste receptacles  
f) Construction and demolition sites without tarps and receptacles to contain debris and waste  
g) Household trash scattered before or during collection

Forbes [4] expands the source (d) to vehicle-related debris which also includes automotive parts and tire scraps that have been fallen on the roads due to collisions or wear and tear.

The 2009 KAB national study [5] represents the likely source of litter for individual items in Figure 2-18. As expected, near 76% of the total roadside litter directly comes from motorists and pedestrians. Moreover, KAB presents the source of litter by each road classification. This result which is shown in Figure 2-19 indicates that the share of each source of litter can vary for different road types. On city roads, pedestrians are the main contributors to the littering problems, while in all other road types motorists are the leading source. The share of untapped loads was found to be the
highest on the state roads and for vehicle debris litter, national roads had a greater portion.

Figure 2-16. An example of an improperly covered receptacle.

Figure 2-17. An example of an unsecured load on a pickup truck on an Interstate.
Figure 2-18. Source of litter on the U.S. roadway. recreated from [5].

Figure 2-19. Comparison of the source of litter by Road type - KAB national 2009 litter study [5].
Forbes (2009) claims that 97% of litter comes from four sources: pedestrians (42%), vehicle occupants (20%), uncovered or unsecured loads on trucks (21%), and open vehicle beds where items had been improperly stowed (14%) [1]. Motorists and pedestrians have also been identified by other studies to be the leading sources of litter for both small and large items. When considering only litter items greater than four inches, improperly secured loads can become a leading source [13].

A recent 2020 study by Burns & McDonnell in Pennsylvania has used slightly different classification for litter sources as six categories: Motorists, pedestrians, improperly secured loads, overflowing containers, vehicle debris, and unknown. This study took an additional step and identified the source of the litter based on the type of the road as well and realized litter source varies by roadway type. The litter source was found to be distinct for each road type. Motorists found to the primary source of litter in all road types. As one might expect, the share of pedestrians is higher on the local roads and lower on interstates which results from the difference in pedestrian volume. Improperly secured loads and vehicle debris have the highest rate in the interstates roadways.

2.2.3 Location and Road type

The type of roadway and the area it is passing through are two factors that can significantly affect the roadside litter rate. In the previous section, we also discussed how the source of litter can vary with the type of road. There are a number of factors that can affect the rate of litter in different locations and road types. Road traffic, road length, population, the distance of businesses and shops to the road, and frequency of
them (specifically fast-food restaurants and convenience stores) are some of the major factors [19].

- **Georgia (2006)**

  The Georgia survey [14] reports the rate of visible litter for different road types and location zones. Figure 2-20 shows those findings which indicate urban freeways have the highest rate of visible litter items per mile followed by rural freeway/toll roads. Residential streets, rural local roads, and streets in front of public facilities with close to 1,000 visible litter items per mile were the least littered roads [14].

![Figure 2-20. Average litter rate by location [14].](image-url)
A specific index was defined by this study to measure the visual impact of the litter which indicates the locations where people are more likely to be exposed to litter. That index was calculated based on the amount of litter and the traffic volume of the road type. The result which is shown in Figure 2-21 indicates that urban freeways and residential streets have the highest rates of exposure with nearly 27% each. Despite the low rate of litter per mile, the high volume of pedestrian and motorist traffic increases the exposure rate.

Overall, in Georgia, urban and rural freeways were found to be the most littered of all roadway types mainly because of their high traffic levels. A high level of negligent litter was also observed on these two roadway types which indicates the impact of unsecured truck loads [14]. Additionally, the higher speed of the vehicle on those roads
can be a contributing factor that causes improperly covered materials to fly out of the vehicles. Mowing is also introduced as a factor that can affect the rate of litter for different locations. This study claims that mowed areas were generally more littered than non-mowed areas.

- **KAB National Study 2009**

  The KAB 2009 national study [5] analyzed the roadway litter result based on the area classification and type of the roadway and determined both the average number of items per mile of the roadway and the total litter. Figure 2-22 shows litter by area classification and demonstrates that the density of the litter is higher in a mile of a road in urban areas. However, the overall number of litter items on rural roads are more than twice as on urban roads, due to more miles. Figure 2-23 displays the number of litter items per mile of the road and the total litter based on the classification of the road. As it can be anticipated, when the traffic volume increases the density of litter on the roadway increases as well, but in terms of total litter over the country, there is more litter on the county roads and state roads because of their higher number of miles.
### Figure 2-22. Litter in the U.S. by urban and rural types [5].

<table>
<thead>
<tr>
<th>Urban Roads</th>
<th>Rural Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7,784</strong></td>
<td><strong>6,357</strong></td>
</tr>
</tbody>
</table>

Average Item per mile  
Total U.S. road Litter (billion)

### Figure 2-23. Litter in the U.S. by roadway type [5].

<table>
<thead>
<tr>
<th>National Roads</th>
<th>State Roads</th>
<th>County Roads</th>
<th>Municipal Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>19,186</strong></td>
<td><strong>13,011</strong></td>
<td><strong>5,539</strong></td>
<td><strong>4,277</strong></td>
</tr>
</tbody>
</table>

Average Item per mile  
Total U.S. road Litter (billion)
2.2.4 Litter Over Time

Concerns about the litter problem in the U.S. has raised since at least 50s when the Keep America Beautiful (KAB) organization was established for the litter prevention premise [1]. The population of the country is growing by 3.5 million per year and more cars are traveling on our roadways, which can potentially aggravate the issue of litter [5]. On the other hand, there have been many efforts in the past few decades to mitigate the litter problem in the U.S., including educational programs, volunteer works, organizations, passing new laws, and imposing fines on litterers. The Institute for Applied Research (IAR), has compared 62 litter surveys that used similar methodologies and found that the average rate of litter has been decreasing by 2% each year (IAR 2006) [1].

The KAB national study [5] also shows some hopeful signs of improvements over the past few decades. A comparison between the national data from 2009 and 1969 surveys shows a significant decrease in the total amount of litter. This comparative analysis suggests that the visible litter has decreased approximately 61 percent in 40 years despite a 50% growth in the population [5]. Figure 2-24 shows this comparison for some of the more critical materials and products. The chart shows significant improvements in reducing the beverage containers, paper, metal, and glass group. However, certain littered materials are increased.

Plastic, in particular, has increased drastically by 165%. One of the explanations for this is the significant surge in the production and use of plastic in our daily life. Plastic is durable, lightweight, and cheap to manufacture which makes it the perfect economic solution for our fast-paced production and consumption culture. In 1950 the world produced only 2 million tons per year. Since then, annual production has
increased by nearly 200-fold, reaching 381 million tons in 2015 [20] It is estimated that 8.3 billion tons of plastic have been created over the past 50 years, only 9% have been recycled, and the rest has gone to landfills or ended up as litter in the environment [21].

Figure 2-24. Change in the litter from 1969 to 2009 [5].

2.3 Safety Impact of Roadside Litter

In addition to the aesthetic and economic impacts, roadside litter can pose safety hazards on the roads and cause vehicle collisions. The most problematic types of litter regarding vehicle collisions are fallen cargo, wheel separations, and other highway debris that can lead to collisions that can lead to injuries and even fatalities. Road debris includes substances, materials, and objects that are foreign to the normal roadway environment. Debris may be produced by vehicular or non-vehicular sources, but in all cases, it is considered as litter [4]. Any cargo that is not covered and secured properly
can be dangerous on the road, even small objects, if segregated from the vehicle and discharged on the road can directly damage other motorists or causing a crash due to other vehicles maneuver for avoidance [4]. The roughness of the road surface can be a major factor in the amount of litter that origins from unsecured loads and smoothing the road can decrease the number of crashes related to lost unsecured loads up to 51% [22].

Forbes (2004) [4] investigates the frequency and severity of Vehicle-Related Road Debris (VRRD) crashes in North America. By applying The VRRD crash rates of 0.2 percent for fatal crashes and 0.4 percent for all other crashes to North American crash statistics for 2001, VRRD was estimated to cause over 25,000 crashes per year, claiming 81 to 90 lives [4]. Although the incidence and severity of VRRD crashes are relatively low, VRRD crashes occur, and transportation agencies should consider low-cost approaches to reducing the incidence [4] Forbes investigates vehicle debris related crashes in a couple of states individually. In Maryland, in a four years period (from 1996 to 2000) 2057 crashes were identified, of those, 34 percent resulted in injuries. Another study in Michigan states debris, oil, and gravel on the road accounted for an average of 4.4% of the serious motorcycle crashes [23]. In the state of Utah, a study [19] analyzed the road accidents from 2008 to 2012 and found between 650 to 800 road crashes happened each year related to litter, five fatal ones among them (Figure 2-25).
VRRD can originate from all types of vehicles, whether as debris of an accident or vehicle parts and equipment that break loose and came off due to wear and tear. Blown tires, tire treads, drive-shafts, fenders, bumpers, hoods, leaf springs, and brake parts have all contributed to serious crashes. Tire scrap makes a big portion of vehicle debris left on the road which is usually a secondary effect of tire blowouts. Maintenance issues (e.g., under-inflation, overloading, tire mismatching, excessive wear, inadequate inspections, and associated matters leading to increased heat and tire operating temperatures) are the major causes of a tire blowout [24].

Such debris may be run over by one vehicle and bounce off the pavement and strike another one [4]. Especially at high speeds, even small debris can cause serious damages to other vehicles. The crashes caused by VRRD or other forms of large litter can happen in various ways, either directly or indirectly. Forbes (2004) [4] describes
eleven scenarios that how debris can lead to a vehicle collision on the road and it is shown in Figure 2-26 to 2-26.

Figure 2-26. Different types of debris related crashes (A-C) [4].
Figure 2-27. Different types of debris related crashes (D-G) [4].
Figure 2-28. Different types of debris related crashes (H-K) [4].

<table>
<thead>
<tr>
<th>H</th>
<th>Pedestrian or maintenance worker struck by motor vehicle while retrieving/clearing debris (outside of vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Pedestrian or maintenance worker retrieving/clearing debris causes road user to perform an avoidance maneuver and lose control</td>
</tr>
<tr>
<td>J</td>
<td>Pedestrian or maintenance worker struck by motor vehicle while retrieving/clearing debris (outside of vehicle)</td>
</tr>
<tr>
<td>K</td>
<td>Pedestrian or maintenance worker retrieving/clearing debris causes road user to perform an avoidance maneuver and lose control</td>
</tr>
</tbody>
</table>
The following recommendations are offered by the means of education and enforcement programs to mitigate the issue of VRRD on the roads by Forbes [4]:

- Educating fleet maintenance personnel on preventing wheel separations
- Training enforcement officials in vehicle safety and load securement
- Training commercial vehicle drivers to periodically inspect their vehicles and cargo
- Educating motorists on load securement and reporting unsafe vehicles, unsecured loads, and road debris
- Enacting stricter laws on load securement
- Targeting specific groups for enforcement (e.g., waste haulers, landscapers)
- Educating the public on defensive driving, especially around trucks

Another safety concern with litter and cigarette butts, in particular, is the risk of fire. Although it is not very common, a flicked lit cigarette butt can potentially put another vehicle on fire. In a very tragic incident in the Mont Blanc Tunnel between France and Italy, in 1999, a cigarette butt caused a fire which led to 39 deaths, $1 million economic loss, and the tunnel being shut down for 3 years. In further investigation, it was revealed that the discarded cigarette was sucked into another vehicle's air intake system and put the air filter on fire [25]. Figure 2-29 shows an image of the massive damage caused by this tragedy.
The safety impact of litter is not limited to motor vehicles and can also affect bicycle and scooter riders. Micromobility is a growing movement in the U.S. Several ride-sharing companies have emerged in the last few years and personal or shared use of bicycles, e-bikes, electric scooters, and other devices has significantly increased. Transportation agencies are also trying to move towards the Complete Street approach and incorporate safe means of transportation for all road users. Litter can impact this group in several ways. Broken glasses and other smaller size solid litter usually end up at the edges of the streets which is the main portion of the road used for micromobility. Further, larger objects are also either dumped on the side of the road or eventually end up there. This can indirectly put riders in danger by forcing them to shift their path towards the center of the road in order to avoid the objects, and consequently increasing the risk of a collision. Bicyclists and scooter riders are considered vulnerable road users who are at a higher risk of severe injuries and fatality if being involved in a crash.
Therefore, providing them with a safe and secure transportation platform can significantly encourage more people to use these devices.

2.4 Cost of Litter

The main economic impact of roadside litter is the enormous amount of money that should be spent on collection and disposal. The KAB 2009 national study estimates that the annual cost of litter removal in the U.S. is almost $11.5 billion, coming from governments, businesses, educational institutions, and volunteer organizations [5]. Such a budget can potentially be saved and put into more essential projects such as improving infrastructures if the litter was properly disposed of in the first place. The financial impact of litter can be both direct and indirect. The cost of collecting litter from roadways is the main direct cost that is mostly imposed on businesses and the government. The indirect cost on the other hand is mostly the economic loss that businesses and individuals experience due to the depreciation of property value and the decrease in sales. Figure 2-30 shows the share of different groups in the direct national cost of litter collection and prevention in the US on an annual basis.
Nelson (2001) [2] gathered information from a number of different states on the budget they spent on litter removal in 1999. Table 2-1 presents this result and shows that the States Department of Transportation (DOTs) have spent nearly $120 million on litter cleanup.
Table 2-1. Estimated annual cleanup costs reported by states [2].

<table>
<thead>
<tr>
<th>State</th>
<th>Annual Costs (Million dollars)</th>
<th>State</th>
<th>Annual Costs (Million dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>2</td>
<td>Missouri</td>
<td>4</td>
</tr>
<tr>
<td>Arkansas</td>
<td>2.18</td>
<td>Nebraska</td>
<td>0.12</td>
</tr>
<tr>
<td>Colorado</td>
<td>3</td>
<td>Nevada</td>
<td>1.8</td>
</tr>
<tr>
<td>Connecticut</td>
<td>2.36</td>
<td>New Hampshire</td>
<td>0.12</td>
</tr>
<tr>
<td>Florida</td>
<td>9.5</td>
<td>New Jersey</td>
<td>5</td>
</tr>
<tr>
<td>Illinois</td>
<td>8.6</td>
<td>New York</td>
<td>0.3</td>
</tr>
<tr>
<td>Indiana</td>
<td>0.94</td>
<td>North Carolina</td>
<td>6.5</td>
</tr>
<tr>
<td>Kansas</td>
<td>0.8</td>
<td>Ohio</td>
<td>2</td>
</tr>
<tr>
<td>Kentucky</td>
<td>5.35</td>
<td>Oklahoma</td>
<td>4</td>
</tr>
<tr>
<td>Louisiana</td>
<td>5</td>
<td>Virginia</td>
<td>6.5</td>
</tr>
<tr>
<td>Maryland</td>
<td>5</td>
<td>Washington</td>
<td>1.8</td>
</tr>
<tr>
<td>Michigan</td>
<td>2.6</td>
<td>West Virginia</td>
<td>1.5</td>
</tr>
<tr>
<td>Minnesota</td>
<td>2</td>
<td>Wyoming</td>
<td>1.5</td>
</tr>
</tbody>
</table>

In 2009, State Departments of Transportation (DOTs) were reported to spend about $430 to $505 for collecting and disposing of litter per centerline mile [1]. Georgia Department of Transportation (DOT) has reported $14 million spent on litter collection in 2006, and a trend of annual increasing costs of 20% [1]. Further, when adding up the local clean-up costs and the costs to other state agencies the overall costs exceeded $20 million per year [14]. A study in Utah [19] analyzed the Utah Department of Transportation data for 2005 to 2012 and reported the annual cost of highway litter cleanup in the range of $1.53 million to $1.83 million. The estimated cost of collecting roadside litter exceeds $130 million per year by state highways alone in 2009 and approaches $500 million by all levels of government [1].
2.5 Environmental Impact

The environmental impact of the roadside litter can go far beyond the boundaries of the roadway network. Toxic materials such as the chemical components of cigarette butts can be washed away with rain and contaminate the soil and the groundwater [27]. Studies have confirmed the impact of the cigarette butt’s toxicity on marine and freshwater fish [28]. Light-weight litter items can be blown by the wind or be carried by the rain runoff and end up in streams, rivers, and drains, and even find their way to the ocean (see Figure 2-31 and Figure 2-32).

Some plastics decompose into microplastics after some time in the ocean, not only polluting the water and harming marine life but also can end up in our food chain [29, 30]. The environmental impact of plastic litter is particularly concerning due to the significant increase in the human desire to use plastic. In 1950 the world produced only 2 million tons per year. Since then, annual production has increased by nearly 200 times, reaching 381 million tons in 2015 [20]. It is estimated that 8.3 billion tons of plastic have been created over the past 50 years, only 9% have been recycled, and the rest has gone to landfills or ended up as litter in the environment [21]. It may take weeks to even hundreds of years for different types of litter to be completely decomposed in nature, and many different species can be harmed during the litter’s so-called afterlife. An animal being trapped or hurt by a piece of litter is an unfortunate but common scene that is a direct consequence of the litter problem. In Britain, there were near 11,500 cases of litter-related incidents reported to the Royal Society for the Prevention of Cruelty to Animals in just one year [1]. It is reported that over 1 million seabirds and 100,000 marine mammals including dolphins and whales are killed by plastic litter [31].
Other than the typical material, often extremely toxic material can be found among the roadside litter. A large portion of the crystal methamphetamine is being created in portable laboratories that frequently dispose of extremely toxic wastes on the
roadsides. In addition to the environmental hazards, this can create a dangerous situation for the clean-up crew and volunteers [1].

2.6 Litter Abatement Strategies

This section explains different strategies for mitigating the roadside litter problem, including prevention and removal methods. There are various aspects to the issue of litter and any long-term solution for mitigating this problem must include engaging communities, continuous educational programs, and encouraging volunteer works [5].

2.6.1 Prevention

There are four major approaches to litter prevention [32]:

• Public awareness and education: media and education campaigns to increase awareness and promote attitude/ behavior change.

• Prompting: providing specific instructions of what to do or what not to do (e.g., “Do not litter”).

• Disposal facilities: planning and designing facilities to encourage appropriate behavior (e.g., providing well-placed trash receptacles).

• Consequence control: positive or negative feedback such as incentives for good behavior and fines or penalties for poor behavior.

Bitgood et al. (1988) [32] claims that consequence control is the most effective method, however, it might not be the most cost-effective one. In addition to these methods, another approach is to target a specific item such as bottle deposit and refund programs [2].
Education, Public Awareness, and Prompting

Education programs to establish anti-litter behaviors are most effective when starting from an early age [2]. Environmental educational materials should be included in the school programs to teach children the proper disposal of trash and recycling principles as well as making them aware of the environmental, social, and economic consequences of littering.

Billboard advertising and paid advertising time on television and the radio are the most commonly used means of reaching large numbers of people. Paid advertisements are proven to be effective in encouraging anti-littering behaviors. Forbes (2009) claims that they prevent littering from occurring at the cost of $0.02 per item and can lead to 70% reductions in litter in 6 years, but they need to be adequately supported and sustained to achieve good results [1]. Some other studies have also shown that research-based advertising if funded and continued for a minimum of five years can be effective in reducing litter in a larger scale [33]. *Don’t Mess With Texas* is a successful example of this kind. The campaign reported in 2013 that 98% of Texas residents are familiar with the slogan, and they had reduced the visible litter by 34% since 2009 [34].

Roadside advertising should boost a sense of social responsibility, educate the public about the fines and consequences of littering, and encourage witnesses to report the litterers. Forbes [1] suggests to increase the effectiveness of roadside advertising the message is better to appear in a series and include a method for reporting the litterers (such as a phone number or a phone app). Schultz [10] claims that using pictures of littered areas and messages that emphasize on the high rate of existing litter can even have a reverse impact because of implying the message that “littering is common”. This study suggest focusing on the fact that littering is wrong and condemned by the majority.
In addition to the conventional means of advertisement such as roadside billboards, and radio, TV social media, and internet websites should be considered as a great way to reach a large audience, particularly, the younger generation who happens to be at the highest risk of littering. While a billboard advertisement can be seen only by hundreds of drivers, a message on social media can easily be seen by millions especially if endorsed by celebrities.

- **Receptacle Design**

  Finnie [35] conducted experiments involved placing litter receptacles along highways and city streets in three cities in the U.S. The Richmond and St. Louis experiments indicate reductions of 16.7% and 14.7% in urban areas and 28.6% along highways. The Philadelphia experiment indicates that litter cans reduce litter by 56% in a clean area and 35% in a dirty area. A more recent effort evaluated the effectiveness of receptacles in reducing litter and found that receptacles average a 40% reduction in litter in both urban and rural settings [1]. Schultz [10] observed that the average distance of litterers from a receptacle was 29 feet, and believes that the availability of receptacle’s can strongly effect the amount of litter.

  As it was discussed earlier, cigarette butts are the most common litter item on the roads, and vehicle occupants are a major source. A significant difference in litter behavior between discarding cigarette butts and other types of litter has been reported [10]. This difference can potentially due to the fact that one can hold on to a fast-food packaging or a piece of paper, but holding to a lit cigarette but can be much more challenging. Schultz’s observations indicated that the availability of ash receptacles is significantly less that regular trash cans and doesn’t meet the need of smokers. Specially
because of the recent policies that bans indoor smoking, more ash receptacles should be provided for smokers in outdoor areas. Anti-litter messages always ask people not to flick their cigarettes out of their vehicles but they rarely offer any alternatives. Smoker drivers might be willing to stop tossing their cigarette butts out of their vehicle if they have a convenient alternative for disposing of it safely in their car. Encouraging drivers to use small trash cans and ashtrays in their cars can be a cheap solution to reducing cigarette litter on the roads.

Ballot Bins is a campaign that was launched in Edinburg and London targeting the general waste and cigarette butts. The beans gave people the option to vote with their litter by asking engaging questions, like choosing between two rival soccer teams, automotive brands, and such (Figure 2-33). This campaign received a great deal of exposure where nearly 90% of the businesses and people in the area were aware of it. In London, the campaign focused on one busy street. Voting-by-bin went viral on social media and the campaign buzz drew 80 inquiries asking to use ballot bins in other areas [34]. The ballot bins cost around $300 and they were proven to reduce cigarette butt littering by 46% [36].
The receptacle should be covered and have the right capacity. Similar to the dumpster shown earlier in Figure 2-16, many trash cans and dumpsters get full sooner than their collection date comes and litter would overflow on their surroundings. Receptacles should also be properly covered to prevent their content from being blown by the wind and scattered around.

- **Consequence Control**

Consequence control through an enforcement program is an essential tool for litter prevention strategies and can be one of the most effective ones. A successful enforcement program needs to be comprehensive and applicable. Effective legislation,
law-enforcement training, and public awareness of the law are some major components of an effective enforcement effort [2]. The consequence control approach in the U.S. can vary from one state to another in terms of the definition of terms, fines, and strictness of the enforcement. Internationally, some countries such as Singapore and Japan are well-known for their severe anti-littering laws and penalties. Littering and illegal dumping can lead to fines and jail sentences in most states of the U.S. However, catching the offenders while committing the crime can be challenging. Most successful cases of enforcement are usually illegal dumping since the act of dumping usually takes longer than littering and there is a higher chance for an officer to catch the offender. Moreover, littering can sometimes be justified as accidental or intentional, dumping is firmly considered as a deliberate act [2]. With the advances in new technologies, catching litterers is becoming more feasible. Using Closed-Circuit Television Cameras (CCTV) can be an effective method especially for illegal dumping hot spots [1]. Some developing technologies such as [37] can even use CCTV recordings to automatically detect any significantly large item that is thrown out of a moving vehicle, identify the vehicle's license plate, and report the case.

2.6.2 Litter Removal

The litter removal programs are mainly done through the state DOTs as a combination of paid crews, volunteer works, and inmate and public service programs. 2 [2] collected the information from 28 states in the U.S. and identified the share of each group which is shown in Figure 2-34. This figure indicates that the DOT maintenance crews account for the majority of the roadside litter collections. Special service crews include paid youth corps, those serving public service sentences, and disadvantaged
worker and work rehabilitation programs. These programs are typically supervised and paid by minimum wage to lower the cost of litter removal compared to a paid maintenance crew or contractors while providing an opportunity for those who need to earn an extra wage. Youth corps is usually a summer program for teenagers. Utilizing youth offenders, community service, and inmate work programs is a more common strategy that runs in many states for non-violent offenders.

The role of maintenance crews and maintenance contractors varies significantly from state to state. In most volunteer programs, volunteers are not allowed to work in hazardous locations and medians due to safety reasons, therefore state maintenance crews and contractors focus on the cleanup of hazardous materials and cleanup in hazardous locations [2].

![Figure 2-34. The average share of different groups in litter pick-up in twenty-eight states [2].](image-url)
Volunteer Programs

Volunteer works have become an important part of the litter removal programs. KAB national study (2008) estimated that volunteer cleanup programs save taxpayers an average of $677 million. As shown in Figure 2-34 volunteer programs account for nearly a third of the roadside litter pick-up efforts. In some states such as Washington and West Virginia, the share of volunteer programs can be even over 80% [2]. Two of the most well-known programs in the U.S. are Adopt-A-Highway (AAH) and Sponsor-A-Highway. AAH originated in Texas in 1985 and since then has spread all over the country and since then it has cleaned over 1 million miles of U.S. highways and interstates [38]. The adoption approach doesn’t limit to highways and there are similar programs for roads, streets, parks, beaches, and hiking trails.

In most AAH programs volunteers will be in charge of cleaning a designated one to three-miles section of the road two to four times per year and in exchange, a sign will be placed in that section to recognizing the volunteer group. For urban streets, the frequency of clean-up can be higher. Program funding typically comes from maintenance budgets or from a state’s general fund or through litter taxes and a variety of environmental grant programs and the corresponding agency will provide safety instruction and operation supplies such as gloves, vests, and trash bags [2].

Sponsor-A-Highway follows a very similar concept to the AAH, except, the sponsor covers the cost and the maintenance provider for litter and debris removal will clean up a specific section of the highway [2]. The monthly cost can vary depending on the level of service and the frequency of it they provide. In return, the state will place a billboard on that section of the road with the name and logo of the sponsor which can
serve as a free advertisement and tends to encourage more businesses and companies to participate in this program.

Maryland State Highway Administration reported that between 1989 and 1999, volunteer workers helped the state save $1.8 million through the AAH program [2]. Despite the benefits of volunteer programs, there are some challenges as well. One of the main concerns raised when some controversial groups tried to participate in the program and have their name and logo on the billboards. Klu-Klux-Klan has done this in several states including Arkansas, Missouri, Florida, Texas, and Maryland. In most cases, the courts have ruled against that, but in some others like in Florida and Arkansas, the court allowed them to continue their participation, which caused a public rage. In Arkansas, some motorists dump trash on that section of the road intentionally to protest against this decision [2].

Another major concern about volunteer work programs is the safety of volunteers. One aspect is being in contact with hazardous types of material and the other is the risk of road accidents between motorists and volunteers. Roadside litter can consist of all sorts of materials and volunteers may encounter sharp objects, medical waste, animals or insects (dead animals, rodents, ticks, and bees), drug-related items (needles, methamphetamine lab material), human urine, and virus-infected items (masks, gloves especially due to COVID-19).

2.7 Summary of Chapter 2

Litter behavioral surveys have shown that the majority of people are aware of the fact that littering is bad, yet many do so because of laziness, lack of ownership to the community, and lack of consequence control. Littering can be classified into two
types of deliberate and negligent littering. Unsecured loads and crash debris forms the majority of the negligent litters. Teenagers and adults younger than 35 were found to be more likely to deliberately litter compared to those in older age groups. Lettering among men was also found to be more common than women.

Multiple surveys found tobacco products to comprise about one-third of the composition of roadside litter, following by miscellaneous paper and plastic pieces and packaging products. More recent surveys show that the percentage of plastic has significantly increased. A comparison between two KAB national studies in 2009 and 1969 shows a significant decrease in some categories of litter such as metal, paper, and glass. However, the rate of plastic litter has increased more than three times in 40 years. Studies have identified seven major sources of the litter as pedestrians/cyclists/motorists, improperly covered dumpsters, loading docks and commercial or recreational marinas with inadequate waste receptacles, construction and sites without tarps and receptacles to contain debris and waste, vehicles with uncovered loads on local roads and highways, and household trash scattered before or during collection.

Locations wise, studies demonstrate that the density of the litter is higher in a mile of a road in urban areas. However, the overall number of litter items on rural roads are more than twice as on urban roads, due to more mile. As can be anticipated, when the traffic volume increases the density of litter on the roadway increases as well. Therefore, high traffic volume roads such as national and state freeways are more littered than the county and municipal roads in terms of the number of litter items per mile.
Litter on the road can even impact the safety and operation of the transportation system. Any litter can pose hazards for motorists, but usually, larger litters are more dangerous and more likely to lead to a crash or cause a delay. Fallen cargo, wheel separations, and vehicle-related road debris can lead to personal injury collisions and even fatalities. However, small litter and cigarette butts can cause a hazard differently by causing a fire. Another form of hazards that can be caused by roadside litter is when animals are absorbed by the leftover food along the road which increases the chance of vehicle-animal collisions.

The KAB 2009 national study estimates that the annual cost of litter removal in the U.S. is almost $11.5 billion, coming from governments, businesses, educational institutions, and volunteer organizations. In addition to the direct cost of removing and disposing of litter, it can also cause an economical loss for businesses and individuals who experience depreciation in their property value and lower sales. Roadside litter collection and disposal can cost about $430 to $505 per centerline-mile.

Litter abatement programs can be focused on prevention, removal, or both strategies. The main approaches toward prevention and changing littering attitudes are increasing public awareness and education, prompting, providing more disposal facilities, and consequence control. The most fundamental approach is through education and increasing public awareness. People must learn the correct way to recycle and dispose of their waste and they should be educated about the environmental consequence of their actions caused by littering. Some studies claimed that consequence control including large fines, and law enforcement is a more effective method to prevent littering especially in short term. However, the most effective approach a comprehensive one that considers all different aspects and uses multiple metrics.
Chapter 3

LITTER IN DELAWARE
Roadside litter is an unfortunate, yet ongoing problem in the state of Delaware. Concerns have been raised in Delaware over the past several years regarding a significant increase in the amount of litter along State highways [39]. During 2016, Adopt-A-Highway volunteers picked up about 2,000 of the nearly 32,000 bags of trash collected along Delaware’s roads [40]. In 2016, as in an annual event hold by Imagine a Litter-Free Delaware Day more than 400 volunteers picked up 3,500 bags of food wrappers and other garbage last year during the event, enough to fill 17 school buses [41].

Illegal dumping is also an issue that is difficult to fight back since only a dozen officers handling environmental crimes across the state, the scofflaws tend to have the upper hand when leaving trash bags, construction materials, and old tires along the highways and byways in Delaware [42]. Figure 3-1 shows some examples of illegal dumping in Wilmington area that was captured on camera by the state police [43]. In 2017, there were 27 individuals arrested, with fines totaling $13,500. Since 2013, the Delaware Department of Natural Resources and Environmental (DNREC) law enforcement officers have only arrested 96 people for "Improper Disposal of Solid Waste." The total fines imposed from 2013 to now are just over $50,000, which is only a fraction of what it costs the state to clean up the discarded this waste [42].

According to Delaware's litter control law [44], anyone who is found guilty of littering or illegal dumping can be fine 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.

Figure 3-1. Examples of illegal dumping in Wilmington [43].

3.1 2018 KDB Survey

Delaware was excluded from the KAB (2008) 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 contractors and sub-contractor. For comparison purposes, this survey was conducted based on the same methodology used by the 2008 KAB national study [5]. 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 which are shown in Figure 3-2. 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 is reported for each group as shown in Figure 3-3. For the smaller group, tobacco and plastic products can be identified as two main categories, accounting for 37% and 32% of this group respectively. On the other hand, for the larger group, plastic is the dominant category that comprises almost half of the litter. Paper account for nearly one-fifth of each group, and the share of metal and glass materials seems relatively insignificant. On average, this survey found 1,120 items per mile for the large litter and 4,967 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 3-4 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 3-5, 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.

Figure 3-3. Composition of litter by material in Delaware [39].
Figure 3-4. The number of litter items per mile at the county, state, and national level [5, 39].

<table>
<thead>
<tr>
<th></th>
<th>KAB 2008 National Study</th>
<th>Statewide</th>
<th>Sussex</th>
<th>Kent</th>
<th>New Castle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small litter (&lt;4&quot;)</td>
<td>6,189</td>
<td>4,967</td>
<td>3,726</td>
<td>3,824</td>
<td>608</td>
</tr>
<tr>
<td>Large litter (&gt;4&quot;)</td>
<td>7,024</td>
<td>1,120</td>
<td>1,224</td>
<td>707</td>
<td>1,269</td>
</tr>
</tbody>
</table>

Figure 3-5. The number of litter items per mile by road function class [39].

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 [13] used a similar method as the one in Delaware and can be used for a side-by-side comparison.
Figure 3-6 and Figure 3-7 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 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 3-6. Small litter by material type in Delaware V.S. Pennsylvania [13, 39].
3.2 Current Efforts in Delaware

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 1,000 members including individuals, groups, and organizations [45]. DelDOT and AAH collect 35,000 bags worth of trash every year, along with 6,000 tires and hundreds of appliances [46]. According to Jennifer Cohan, the Secretary of Transportation, DelDOT invests about $2 million on litter cleanup across the state annually [9]. DelDOT had an additional $750,000 in its budget in 2020 for contractual trash pickup on Delaware roadways [46].

Delaware’s Governor, John Carney, has addressed the issue of litter in Delaware and the illegal dumping problem, particularly in Sussex County [47]. 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 [9]. While volunteers are mostly prohibited from work on high-risk locations such as interstate, usually contractors and DOT 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 litter. 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 [48].

According to Delaware's litter control law [44], “a person who is found guilty of littering or illegal dumping can be fine 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 [49].

Regarding illegal dumping, the minimum penalty fee increases to $500 and $1,000 for the first and subsequent offenses respectively. However, illegal dumping can be challenging to fight back. Since only a few officers handling environmental crimes across the state, getting away with illegal dumping can be easy for the offenders [42]. Since 2013, the Delaware Department of Natural Resources and Environmental (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 a fraction of what it costs the state to clean up and properly dispose of this waste [42].

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.
3.3 Summary of Chapter 3

A survey by KDB in 2018 showed that the rate of large litter in Delaware litter is near twice the national average. It was estimated that there are 1,120 pieces of litter per centerline road mile for those larger than four inches, and nearly 5,000 pieces of litter per mile for smaller items. New Castle County had the highest rate of litter items per mile for both small and large litter categories, but it is also the most populated county. In terms of road type, interstates had the highest litter rate, followed by U.S. Highways, and State Roads, which can be expectable with regards to their traffic volume. DelDOT is putting lots of effort and funding towards removing litter from roadsides by investing about 2 million dollars annually.

AAH program is becoming more popular in Delaware and several other campaigns including Keep Delaware Litter Free and Work a Day Earn a Pay have been launched in the past few years in response to the litter problem. However, their message and slogan need to be spread on a bigger scale to educate more people and inform them about the consequences of littering. Although there were some cases that the offender was arrested and fined, the total fines imposed from 2013 to now are just over $50,000, which is only a fraction of what it costs the state to clean up the discarded this waste, and stricter penalties and consequence control methods are required.
Chapter 4

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS
4.1 Summary and Conclusions

Roadside Litter is an ongoing problem that many countries around the world are struggling with. Fast food packages, drink containers, plastic bags, vehicle debris, illegal dumping, and many other types of litter sitting alongside the roadways. This might be an unpleasant yet familiar scene for most of us. Growth of the population, increase in vehicle-miles-traveled (VMT), and consuming more products are factors that can have contributed to aggravating this problem. Moreover, the global pandemic due to Covid-19 raised a new issue as the number of personal protection products in litter drastically increased.

The amount of litter along State highways in Delaware has significantly increased in the past few years. Illegal dumping is another issue in the state and Sussex county in particular. Some people refuse to pay for properly disposing of their waste and instead dump it along the roads. In addition to aesthetic issues, litter can pose safety hazards on the road for motorists, pollute the environment, cause fire, harm the wildlife, and cost a lot to be removed. Although there are fines and penalties for this illegal act, most offenders will get away with that since law enforcement can not proportionately respond. As a result, DelDOT spends about $2 million annually on litter cleanup. This report makes an effort to study different aspects of this problem by reviewing the relevant publications and find the best practices for the state of Delaware.

The term litter refers to any misplaced solid waste and littering is considered a social problem caused by the misbehavior of individuals. Although most surveys have shown that the majority of people are aware of the fact that littering is bad, yet many do it. There are two main types of littering, deliberate and negligent. An example of negligent littering can be items fall of an unsecured load or crash debris.
Lack of ownership can be one of the main reasons that cause people not to consider themselves responsible for cleaning the public environment and believing that someone else will clean up after them. Teenagers and adults younger than 35 were found to be more likely to deliberately litter compared to those in older age groups. Lettering among men was also found to be more common than women.

The KAB national study in 2009 [5] estimates there are 51.2 billion pieces of litter on the roadways in the US, 91% of which being less than four inches in size. Multiple surveys found tobacco products to comprise about one-third of the composition of roadside litter, following by miscellaneous paper and plastic pieces and packaging products. More recent surveys show that the percentage of plastic has increased. A comparison between two KAB national studies in 2009 and 1969 shows a significant decrease in some categories of litter such as metal, paper, and glass. However, the rate of plastic litter has increased more than three times in 40 years. Studies have identified seven major sources of the litter as follow:

- Pedestrians or cyclists
- Motorists
- Business dumpsters that are improperly covered
- Loading docks and commercial or recreational marinas with inadequate waste receptacles.
- Construction and demolition sites without tarps and receptacles to contain debris and waste.
- Trucks with uncovered loads on local roads and highways.
- Household trash scattered before or during collection
Locations wise, studies demonstrate that the density of the litter is higher in a mile of a road in urban areas. However, the overall number of litter items on rural roads are more than twice as on urban roads, due to more mile. As can be anticipated, when the traffic volume increases the density of litter on the roadway increases as well. Therefore, high traffic volume roads such as national and state freeways are more littered than the county and municipal roads in terms of the number of litter items per mile.

Litter on the road can even impact the safety and operation of the transportation system. Any litter can pose hazards for motorists, but usually, larger litters are more dangerous and more likely to lead to a crash or cause a delay. Fallen cargo, wheel separations, and vehicle-related road debris can lead to personal injury collisions and even fatalities. However, small litter and cigarette butts can cause a hazard in a different manner. The most tragic example of that was the Mont Blanc tunnel fire in a Tunnel between France and Italy in 1999. A lit cigarette butt that was flicked out of one vehicle was sucked into another vehicle's air intake system and caused a fire that led to 39 deaths, $1 million economic loss, and the tunnel being shut down for 3 years. Another form of hazards that can be caused by roadside litter is when animals are absorbed by the leftover food along the road which increases the chance of vehicle-animal collisions.

The KAB 2009 national study estimates that the annual cost of litter removal in the U.S. is almost $11.5 billion, coming from governments, businesses, educational institutions, and volunteer organizations [5]. In addition to the direct cost of removing and disposing of litter, it can also cause an economical loss for businesses and individuals who experience depreciation in their property value and lower sales. A
survey of state DOTs in 2009 revealed that the cost of roadside litter collection and disposal is about $430 to $505 per centerline-mile [1].

Litter abatement programs can be focused on prevention, removal, or both strategies. The main approaches toward prevention and changing littering attitudes are increasing public awareness and education, prompting, providing more disposal facilities, and through consequence control. The most fundamental approach is through education and increasing public awareness. People must learn the correct way to recycle and dispose of their waste and they should be educated about the environmental consequence of their actions caused by littering. Some studies claimed that consequence control including large fines, and law enforcement is a more effective method to prevent littering especially in short term. However, the most effective approach a comprehensive one that considers all different aspects and uses multiple metrics. “Don’t mess with Texas” is a successful example of anti-litter campaigns in the US.

Litter is a universal problem and many countries all over the globe are struggling with that, and correspondingly many efforts have been undertaken to mitigate this issue. Some of the successful international campaigns and innovative ideas were discussed in this report. Ballet bins in London was a great example of an anti-litter campaign, that chose a different approach and instead of shaming the litterers, they turned it into a fun activity that people could vote on a fun question using their cigarette butts. This campaign was found very effective in a city environment. In Stockholm Sweden, McDonald’s started a campaign that trades burgers for recyclable cans. Similar ideas for rewarding money or coupons for returning recyclable material have been used in various forms. Envirobank is an example of rewarding vending machines that was launched in Queensland, Australia.
A survey by KDB in 2018 showed that the rate of large litter in Delaware litter is near twice the national average. It was estimated that there are 1,120 pieces of litter per centerline road mile for those larger than four inches, and 4,967 pieces of litter per mile for smaller items. New Castle County had the highest rate of litter items per mile for both small and large litter categories, but it is also the most populated county. In terms of road type, interstates had the highest litter rate, followed by U.S. Highways, and State Roads, which can be expectable with regards to their traffic volume.

DelDOT is putting lots of effort and funding towards removing litter from roadsides by investing about 2 million dollars annually. AAH program is becoming more popular in Delaware. In 2018 the AAH program had over 1000 participating groups who collected over 5000 bags of litter and 6000 tiers throughout the year. Several other campaigns including Keep Delaware Litter Free and Work a Day Earn a Pay have been launched in the past few years in response to the litter problem. However, their message and slogan need to be spread on a bigger scale to educate more people and inform them about the consequences of littering. The most recent step for Delaware towards reducing the use of plastic was passing House Bill 130. This bill bans the use and distribution of single-use plastic carryout bags at retail stores starting Jan 1st of 2021. This is a progressive step that not only can result in a reduction of plastic use in general but also anticipated to reduce the plastic bags as roadside litter.

Some areas are specifically suffering from illegal dumping, as state officials have addressed this issue, particularly for Sussex County. Although there were some cases that the offender was arrested and fined, the total fines imposed from 2013 to now are just over $50,000, which is only a fraction of what it costs the state to clean up the
discarded this waste, and there is a need for establishing more effective consequence control methods and stricter enforcement of the penalties.

4.2 Recommendations

The following recommendations are made for this project based on the findings described in the report and mainly experiences of the effective litter abatement programs at the national and international level.

➢ Public Awareness and Prompting

- Utilizing various forms of advertisements such as billboards, radio and TV, social media, and posters to educate people about properly disposing of their waste and recycling. Moreover, informing them about fines and penalties for littering and illegal dumping and offering a practical and easy method for reporting the litterers.

- Campaigns such as “Keep Delaware Litter Free”, “Work a Day Earn a Pay”, and their slogans need to be advertised through different methods so the public will be well aware of them (Like the “Don’t Mess With Texas” campaign).

- Encouraging more people to join the Adopt-A-Highway and businesses to participate in the Sponsor-A-Highway program.

- Encouraging different departments in the University of Delaware and other colleges and educational institutions to participate in the AAH
program. A similar idea can be applied to governmental agencies and private companies.

- Give direct messages on events and occasions with potential for litter generation, such as sports games. Even an audio message from the announcer or showing a visual message on the scoreboard can make a difference.

- Distributing car trash cans and ashtrays for free or at a low price in dealerships to put in all selling cars or directly to drivers at DMV, toll stations, or similar places.

Law enforcement

- Training officers for strict enforcement of the law for littering and vehicles with unsecured loads on highways.

- Increasing the fines and penalties for littering, especially since Delaware’s current fines are much lower than many other states.

- Using CCTV and advanced technologies for monitoring and law enforcement purposes in locations that are struggling with the illegal dumping problem.

- Developing practical and easy methods (e.g. mobile apps, phone numbers, etc.) for reporting a litterer. However, it should be noted that even best methods will not be effective if no one knows about them, and advertisement is necessary for that matter.
➢ **Road safety**

- Educating people about securing their cargo as well as the laws and fines for those who travel with an unsecured load.
- Educating people about the danger of flicking cigarette butts and the potential hazard of causing fire for other vehicles.
- Smoothing the road in the locations that fallen cargo of the vehicles is a problem, can decrease this rate.
  - Advertising methods that people can contact DelDOT when witnessing a hazardous situation caused by a debris object on the road.

➢ **Covid-19 Response**

- Encouraging businesses to place extra trash cans near the exit area of places where people usually use masks and gloves, such as hospitals, clinics, care centers, banks, grocery shopping centers, and other retail stores such as shown in Figure 4-1. Adding instructional posters near the trash cans such as the one shown in Figure 4-2 can increase their effectiveness.
- Specific instructions should be given to people through online ads, billboards, posters, radio ads, and other forms to encourage them to dispose of their masks, gloves, and wiping pads properly and emphasizes that these materials are not recyclable, and should only be trashed.
Figure 4-1. Placing trash cans dedicated to personal protective equipment [50].

Figure 4-2. An example of a poster message related to disposing of personal protective equipment [51].
Innovative ideas

- Ballet bins can be an effective method for reducing cigarette butts in crowded urban environments. Figure 4-3 shows an example of ballet bins with a suggested question for Delawareans.

![Ballet bin example](image)

Figure 4-3. An example of suggested ballet bins for Delaware [34].

- The rewarding vending machine such as the one shown in Figure 4-4 is another positive encouragement where people can drop off their recyclable material and receive, cash, coffee coupons, movie tickets, and
other forms of rewards. This method is most useful in an urban environment and can be located in places such as shopping centers.

Figure 4-4. A reverse vending machine in Australia [52].
REFERENCES


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