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CIGARETTE WASTE AS A NEGLECTED ENVIRONMENTAL AND PUBLIC HEALTH CRISIS: PERSISTENT POLLUTION, TOXIC EXPOSURE, AND ENVIRONMENTAL INEQUITY

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ABSTRACT

Cigarette waste constitutes the most abundant form of solid waste collected globally, yet it occupies a paradoxical position: simultaneously ubiquitous and overlooked, materially persistent and culturally normalized. This paper critically examines cigarette waste as an environmental externality of tobacco consumption, which is embedded within intersecting systems of industrial accountability, regulatory failure, and environmental injustice. Drawing on a recent review of peer-reviewed literature published, we interrogate the composition and environmental persistence of cigarette filters, principally cellulose acetate, alongside their chemical, ecological, and public health consequences. Trillions of cigarette butts are discarded annually, releasing nicotine, lead, cadmium, and microplastic fibers into soils, waterways, and coastal ecosystems, with measurable consequences for aquatic life, wildlife, and human health, particularly among children and communities with elevated environmental exposure.

Beyond cataloging these impacts, we situate cigarette waste within broader political economies of pollution: the tobacco industry's historic evasion of extended producer responsibility, the disproportionate burden borne by low-income and marginalized communities, and the persistent gap between tobacco control policy and environmental governance. We contend that the uneven geographic distribution of cigarette litter reflects not simply individual behavior, but structural inequalities in retail density, municipal resources, and regulatory enforcement. We further explore emerging possibilities for waste reuse and material recovery, from construction materials and carbon electrodes to acoustic insulation and corrosion inhibition, while attending to the tensions and contradictions these innovations introduce when the source material remains inherently toxic.

The paper demonstrates that addressing cigarette waste demands a shift from individualized littering discourse toward systemic accountability, encompassing extended producer responsibility, regulatory reform, environmental justice, and the meaningful integration of waste reduction into public health frameworks. In doing so, it contributes to wider scholarly conversations about how waste is produced, distributed, and governed under conditions of structural inequality, and calls for cigarette waste to be recognized as both an environmental justice concern and a neglected frontier in waste studies.

Keywords: Cigarette waste, Pollution, Health, Environment, Policy, Reform, Tobacco

1 INTRODUCTION

Tobacco use is linked to well-known health issues like lung cancer, Chronic obstructive pulmonary disease (COPD), heart disease, and respiratory problems (Aslam et al., 2025; Lu et al., 2024). In addition, they emit air pollutants that affect people's health. About 23% of the global population is addicted to cigarettes, with 32% of men and 7% of women. Eastern and Southeast Asia have the highest smoking rates at 45%, while the Caribbean and North America have the lowest at 20% (Gowing et al., 2015). In 2021, 18.7% of U.S. adults used tobacco (Cornelius et al., 2023), mainly cigarettes (11.5%) and e-cigarettes (4.5%). Tobacco differs across age groups, with 17% of adults aged 18 to 24, 22.1% of those aged 25 to 44, 21.1% of adults aged 45 to 64, and 11% of seniors aged 65 and older using tobacco (Aslam et al., 2025). From the research conducted by respondents in the United States, a lot of smokers (74.1%) admit to having littered cigarette butts at least once, either by discarding them on the ground or throwing them out of a car window. Additionally, 55.7% have reported disposing of cigarette butts on the ground, in a sewer or gutter, or down a drain within the past month (Rath et al., 2012).

The environmental damage caused by tobacco, particularly cigarette waste, persists in harming both the environment and public health. A lot of smokers throw cigarette butts onto sidewalks, into gutters, or directly into water sources (Rath et al., 2012). Cigarette butts were also the most collected items during clean-up efforts in other locations, including retail areas, storm drains, loading docks, construction sites, parks, and playgrounds (Rath et al., 2012). The amount of this waste is massive, with trillions of cigarette butts being discarded each year globally, a significant share of which comes from the U.S. An economic analysis found that cities the size of San Francisco spend, on average, between \$500,000 and \$6 million annually to keep their streets and parks clear of cigarette litter (Schneider et al., 2011a). Also, when there are cleaning activities around the world, cigarette butts are the most commonly thrown garbage items on the planet (Bonanomi et al., 2020; Desideri et al., 2019; Green et al., 2019). Cigarette butts also rank first in abundance in garbage that is collected every year on beaches all over the world, and it makes up to 40% of the total marine debris that is collected (Conradi and Sánchez-Moyano, 2022a; Hidalgo-Ruz et al., 2018).

Cigarette butts do not just generate litter, but they also contain toxins that stay in the environment, harming ecosystems and human health. Cigarette filters mainly consist of cellulose acetate, a type of plastic that is not readily broken down by microorganisms (Joly and Coulis, 2018). Instead of decomposing, these filters break down into tiny plastic particles and release chemicals like nicotine, lead, cadmium, and formaldehyde into the environment. These chemicals threaten aquatic life, land animals, and children who might meet them in parks and playgrounds. Also, as a result of the environmental persistence of cigarette waste, they remain in the environment even after it is cleaned by organized garbage collection events (Loizidou et al., 2018). Cigarette waste has been found to accumulate in several places in cities, in areas like store centers, parks, restaurants, and bars, as well as on beaches, where they stay longer than in urban areas (Gholami et al., 2020).

Although tobacco control efforts in the United States have successfully reduced smoking rates, cigarette waste continues to be an essential and increasingly urgent issue (Bafunno et al., 2020). The disconnect between public health policies and environmental regulations has created a gap that needs to be addressed. In this paper, we examine the scope of this problem, discuss its implications for public health, and offer clear, practical recommendations tailored to global needs and infrastructure.

2 RESEARCH METHODOLOGY

This study utilized a review approach to examine the environmental and public health implications of cigarette waste. The primary objectives were to evaluate the composition and persistence of cigarette waste, its ecological and health impacts, and the effectiveness of policy solutions to mitigate these effects. A narrative literature review was conducted to synthesize existing studies, and both qualitative and quantitative data were analyzed to address the research questions.

2.1 Literature Review

A narrative literature review was conducted to identify and synthesize relevant peer-reviewed studies. A comprehensive search was performed using major academic databases, including PubMed, Google Scholar, and Scopus. The time frame for the review was restricted to studies published between 2010 and 2025, ensuring that only the most recent research was included. The focus of the literature review was on studies that addressed the environmental persistence of cigarette waste, the chemical composition of cigarette filters (particularly non-biodegradable cellulose acetate), and the associated risks to ecosystems and public health. Additionally, studies were included if they assessed the effectiveness of policies or interventions to reduce cigarette waste, such as anti-littering laws, public education campaigns, and recycling initiatives.

2.2 Study Selection Criteria

Studies were selected based on several key criteria. First, only those specifically addressing cigarette waste were included. These included studies examining the environmental persistence of cigarette butts and the leaching of harmful chemicals, such as nicotine, cadmium, and lead, into ecosystems. Second, geographical relevance was a determining factor, with preference given to studies conducted in the United States, especially those focusing on urban areas where cigarette waste poses a significant environmental concern, such as San Francisco. Third, methodological rigor was essential; only peer-reviewed articles with clearly defined research methodologies were considered. Both qualitative studies, such as surveys and interviews, and quantitative studies, including environmental impact assessments and cost-benefit analyses, were eligible. Finally, studies evaluating the effectiveness of policies aimed at addressing cigarette waste, such as anti-littering regulations, smoking bans, and waste management strategies, were prioritized. In total, 40 studies met these criteria and were included in the review.

2.3 Data Collection

The data for this study were collected from a variety of sources, including peer-reviewed journal articles, government reports, and policy documents. The data were categorized into three main areas: environmental impact, public health, policy, and behavioral data. Environmental impact data included studies assessing the persistence of cigarette waste across urban, coastal, and forested ecosystems. Information on the chemical composition of cigarette filters and the environmental costs associated with cleanup efforts, particularly in high-litter areas like San Francisco, was also collected. Public health data comprised research on the health risks associated with exposure to toxic chemicals from discarded cigarette butts, including substances like nicotine, cadmium, and lead. Studies examining the broader impacts of cigarette waste on wildlife, water quality, and human health were also included in this category. Policy and behavioral data involved data on smoking behaviors, specifically the frequency of cigarette butt littering. Surveys and reports providing insights into public perceptions of cigarette waste and the effectiveness of anti-littering campaigns and policies were reviewed to assess the role of policy in addressing the issue.

3 COMPOSITION AND PERSISTENCE OF CIGARETTE WASTE

Cigarette butts are made of a filter made from cellulose acetate, a type of plastic that can take over a decade to break down in the environment (Green et al., 2020). These filters are designed to trap tar and other chemicals from tobacco smoke, but when discarded, they retain many of these toxicants. A single cigarette butt can contain hundreds of chemicals, many of which are known carcinogens, reproductive toxins, and environmental pollutants (Green et al., 2020; Slaughter et al., 2011).

Cigarette butts are categorized alongside plastic items in most publications examining marine debris worldwide; however, recent authors have regarded them as a separate category, primarily due to their high abundance (Araújo and Costa, 2021). Cigarette butts contribute to 0.3 to 0.8 million tons (Belzagui et al., 2021) of the approximately 8 million tons of plastics (Jambeck et al., 2015) entering the marine environment. Cigarette butts release tiny microfibers daily, which can persist for up to 30 years because the fibers are non-biodegradable (Gerritse et al., 2020).

Heavy metals like lead and cadmium, nicotine residues, and volatile organic compounds are also in cigarette products (Gerritse et al., 2020). These chemicals leach into soil and waterways, especially during rain, and contribute to pollution of natural ecosystems (Green et al., 2020). Cigarette butts have also been shown not just in releasing harmful toxins but also in absorbing toxins from the surrounding marine environment, thereby acting as a dangerous vector of pollutants that contaminate distant ecosystems (Acosta-Coley et al., 2019; Santos-Echeandía et al., 2020). Beyond chemical toxicity, the sheer volume of cigarette waste adds a physical burden to the environment. It clogs storm drains, contributes to urban blight, and introduces microplastics into aquatic ecosystems (Acarer Arat, 2024). In coastal cities and beach communities, cigarette butts consistently top the list of the most commonly collected items during cleanup events (Araújo and Costa, 2019a).

4 ENVIRONMENTAL IMPACT OF CIGARETTE WASTE

Globally, humans generate an immense volume of cigarette waste each year. Public spaces such as sidewalks, parks, beaches, and transit stations are often littered with cigarette butts. Municipalities spend millions of dollars annually on tobacco-related litter cleanup (Lam et al., 2022; Rath et al., 2012).

In 2022, about 124 billion cigarette butts were littered in the United States. The environmental burden of cigarette waste is felt in both urban and rural areas. Cigarette butts are typical litter found on beaches and in urban environments (Valiente et al., 2020; Yousefi Nasab et al., 2022). In the United States, for example, Cigarette butts are unevenly scattered, with higher concentrations in census tracts grouped near urban areas, especially in neighborhoods already burdened by environmental and social challenges (Lowe et al., 2024a). In urban settings, cigarette butts are swept into stormwater systems and end up in rivers, lakes, and oceans. In natural areas, discarded butts pose threats to wildlife that may ingest them or be exposed to leached chemicals. Coastal ecosystems are particularly vulnerable. Marine animals, including fish, sea turtles, and birds, have been found with cigarette butts in their digestive tracts, which can lead to internal injuries or death (Slaughter et al., 2011; Yang et al., 2023).

In addition to the harm caused by ingestion, chemicals from cigarette filters also affect water quality. Research has shown that even a single cigarette butt soaked in a liter of water can kill small aquatic organisms (Novotny and Slaughter, 2014; Slaughter et al., 2011). The accumulation of such waste, especially in regions where cigarette consumption remains high, represents a silent but deadly form of pollution that undermines biodiversity and water safety.

5 PUBLIC HEALTH IMPLICATIONS

The direct health effects of smoking and the indirect public health consequences of cigarette waste are well-established (Bafunno et al., 2020; Novotny and Slaughter, 2014). In the United States, cigarette smoking is projected to account for at least 480,000 deaths per year (HHS, 2014). Cigarette smoke contains more than 7,000 chemicals, and inhaling cigarette smoke exposes the cigarette smoker to these numerous toxins, which include the various tobacco constituents and the products of pyrolysis (Bonnie et al., 2015). Repeated inhalation of a complex mixture of cigarette smoke toxins at high daily doses over many years leads to a wide range of short-term and long-term health issues that impact most major organs (Franklin Akwasi Adjei and Augustine Afriyie, 2025). In the short term, smoking reduces overall health status, as indicated by various measures such as physiological biomarkers, self-reported health, increased vulnerability to acute illnesses and respiratory symptoms, and increased school and work absences. Long-term health effects include smoking-related diseases that are leading causes of death in middle- and upper-income countries, such as coronary heart disease, cancer, and chronic obstructive pulmonary disease (Bonnie et al., 2015). Children are especially vulnerable because when they play in parks or sandboxes, they may pick up and ingest cigarette butts, causing accidental nicotine poisoning. Poison control centers in the United States receive numerous calls each year related to such incidents, although these occurrences are uncommon (Novotny et al., 2011). In densely populated neighborhoods, especially in low-income and marginalized communities, cigarette litter exacerbates environmental inequity (Novotny and Slaughter, 2014). Residents of these areas often face higher concentrations of tobacco retailers and smoking activity, and consequently, more tobacco-related waste. This compounds the burden of pollution already borne by underserved populations and undermines environmental justice. Furthermore, smoke residual chemicals from tobacco smoke that settle on surfaces and materials can also originate from discarded cigarette butts, and this is known as thirdhand smoke (Jacob et al., 2017). When people are exposed to these residues through contact with litter in parks, sidewalks, or apartment common areas, they may face chronic exposure to carcinogens.

6 ECONOMIC COST OF CIGARETTE WASTE

One of the hidden economic costs is the disposal and cleanup of tobacco product waste, including cigarette butts, packaging, and other tobacco-related litter. This waste management burden arises from the need for municipalities and governments to allocate resources to prevent, properly dispose of, or clean up tobacco-related waste in public spaces. Numerous studies have quantified these costs at the national or subnational level, revealing the scale of this economic burden. Several studies have examined the financial impact of tobacco product waste, and the findings are striking. For instance, research in the UK found that the annual cost of managing tobacco product waste was US\$55 million ("UK warns big tobacco firms," 2021). This estimate reflects the costs borne by local authorities and waste management organizations, as well as public health initiatives aimed at reducing tobacco litter. Direct measurement methods were used to estimate that the annual cost of tobacco product waste in France was approximately US\$ 93 million ("Tobacco manufacturers to pay for cigarette butt clean-up in France," 2021). This cost includes expenses for the collection, disposal, and cleanup of cigarette butts and other tobacco-related litter nationwide. In the United States, a proportional estimation approach was used to calculate the tobacco waste costs in 30 of the largest cities. The combined total for these cities was a staggering US\$ 265 million annually (Schneider et al., 2020a). The large-scale nature of this estimate

underscores the significant impact of tobacco waste on urban areas, which face challenges in keeping public spaces clean and free of cigarette-related debris. A more localized study in San Francisco estimated the cost of tobacco product waste cleanup at US\$ 6 million annually (Schneider et al., 2011b). This figure represents a smaller geographical area, but it still reflects the substantial financial commitment required to manage cigarette litter. Regular beach cleaning is essential to supporting tourism, particularly because many travelers are drawn to coastal environments. Global tourism has continued to expand in recent years, demonstrating that it is one of the most profitable and resilient sectors of the world economy. This trend is especially evident in coastal countries with temperate climates, such as Spain, which remains one of the most visited destinations internationally (Conradi and Sánchez-Moyano, 2022b).

During the summer months, when coastal populations increase due to tourism, waste management becomes more difficult (Asensio-Montesinos et al., 2019). The quantity of litter found on beaches often doubles compared to other times of the year, placing additional pressure on local management efforts and threatening the long-term attractiveness of tourist destinations (Araújo and Costa, 2019b).

Improper cigarette butt litter disposal significantly raises the risk of fires in forests and buildings. In some countries, hundreds of thousands of fires each year are attributed to discarded cigarette waste, resulting in substantial financial losses related to fire suppression efforts, property damage, and long-term environmental harm (Beutel et al., 2021; Krelling et al., 2017; Leistikow et al., 2000). Additional expenses arise from policy measures aimed at reducing cigarette butt litter. These include the costs incurred by public institutions to create and enforce regulations, along with the purchase of trash bins, ashtrays, and other receptacles (Schneider et al., 2020b).

Table 1: Pathways of Cigarette Exposure and their Health and Environmental Impacts

Exposure pathway	Health and environmental impacts
Plastic filter persistence	Long-term accumulation of cellulose acetate fibers and microplastics in soil and aquatic environments (Acosta-Coley et al., 2019; Gerritse et al., 2020; Green et al., 2019; Joly and Coulis, 2018)
Chemical leaching from discarded butts	Release of nicotine, lead, cadmium, and other toxicants into surrounding soil and water, particularly following rainfall events (Gerritse et al., 2020; Green et al., 2019; Slaughter et al., 2011).
Stormwater transport	Movement of cigarette waste from streets and drains into rivers, lakes, and coastal waters, expanding the geographic reach of contamination (Acarer Arat, 2024; Araújo and Costa, 2019b; Rath et al., 2012)
Aquatic toxicity	Exposure to cigarette butt leachate causes mortality and sublethal effects in freshwater and marine organisms (Novotny et al., 2011; Yang et al., 2023).
Wildlife ingestion	Ingestion of cigarette butts and filter fragments by birds, fish, and other wildlife leads to physical injury and chemical exposure (Slaughter et al., 2011; Yang et al., 2023).
Child contact and ingestion	Contact with or ingestion of discarded cigarette butts by children in parks and residential spaces poses nicotine poisoning risks (Novotny et al., 2011).
Microplastic dispersal	Fragmentation of cigarette filters into microplastic fibers that persist and circulate in aquatic and terrestrial ecosystems (Gerritse et al., 2020; Morgan et al., 2022; Shen et al., 2021a).

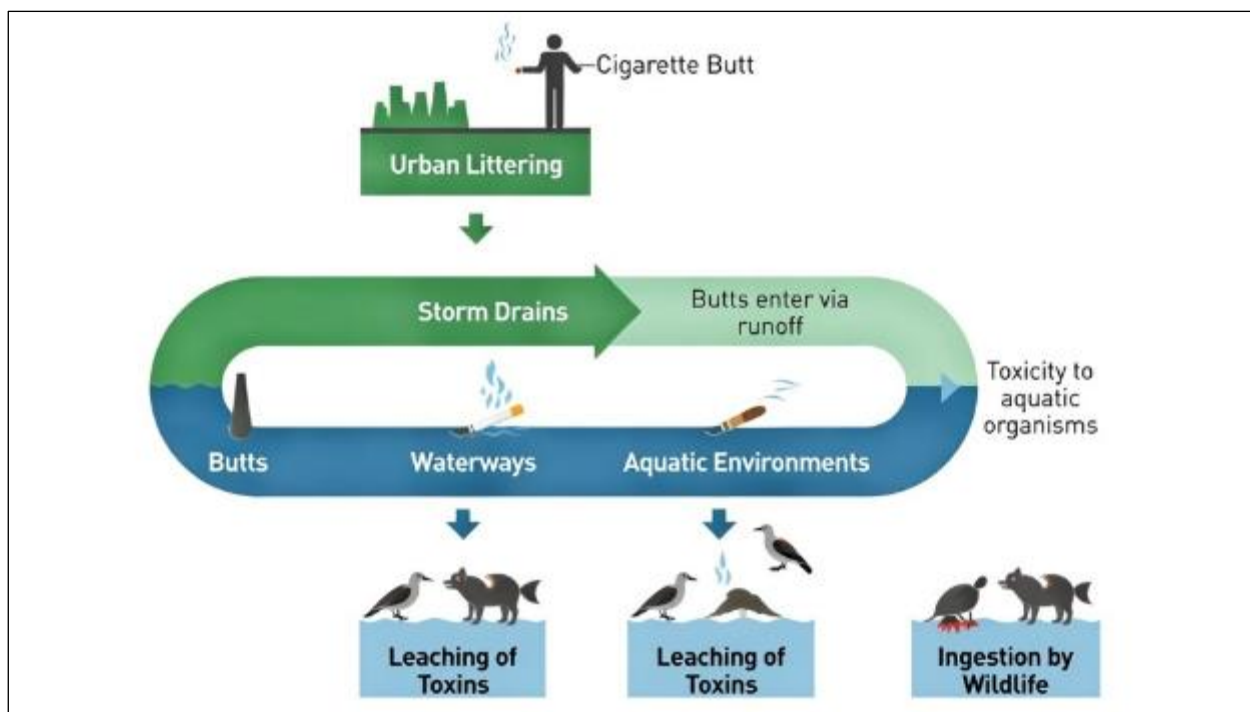


Figure 1: Pathways of cigarette litter and impacts

7 DISCUSSION

7.1 The Role of Regulation and Policy Reform in Controlling Cigarette Waste

A comprehensive approach to reducing cigarette waste must begin with regulatory reforms that hold tobacco and cigarette companies accountable for the environmental impact of their products. One of the first steps in this process is to regulate cigarette waste as a form of plastic pollution. There are numerous options, including surcharges, levies, taxes, and fees, that can be considered to hold the tobacco industry accountable for these costs. In addition to regulatory measures, stricter anti-littering laws are essential to curb the disposal of cigarette butts in public spaces. Research indicates that anti-littering messages more effectively increase intentions to avoid littering in the following month than chemical messages (Morgan et al., 2022). These messages also boost awareness that cigarette butts are the most common litter, encourage more discussions about littering, and promote reflection on proper cigarette disposal (Morgan et al., 2022). Additionally, using cigarette packs with anti-littering labels resulted in fewer weeks of littering from car windows than packs with chemical labels, although it did not entirely stop the act of littering cigarette butts (Morgan et al., 2022). While many smokers may be unaware of the environmental consequences of their actions, imposing fines or penalties for cigarette littering could help change behavior by making it a consequence. The advent of artificial intelligence (AI) enables us to leverage AI-powered monitoring systems to track cigarette waste-disposal patterns in urban and marine environments. Using AI algorithms, data from sensors or cameras can be analyzed to identify high-litter areas, monitor trends, and predict where cigarette waste is likely to accumulate (Chacón-Albero et al., 2025).

Municipalities should also establish designated cigarette waste disposal bins in high-foot-traffic areas, such as parks, transit stations, and beaches. These bins would provide smokers with an accessible, responsible way to dispose of cigarette butts, thereby reducing the likelihood of littering.

7.2 Public Education and Awareness Campaigns

Public education plays a pivotal role in addressing cigarette waste. The intricate psychology behind butt littering renders it challenging to identify any message that could potentially alter the behavior (Smith and Novotny, 2011). However, a well-structured educational campaign that highlights the environmental impact of cigarette waste could alter public perception and promote responsible cigarette disposal. The emphasis should be on raising awareness and fostering collective positive action. These campaigns ought to focus on the long-term ecological harm caused by cigarette litter, the toxic chemicals it releases, and the threat it poses to ecosystems. Research has shown that educational and awareness campaigns are effective methods of reducing the waste caused by cigarette litters (Torkashvand and Farzadkia, 2019).

In addition to formal educational initiatives, community-led programs may bolster collective responsibility for cigarette waste. Engaging residents in cleanup activities can cultivate a sense of ownership and accountability for the environmental health of public spaces, and it has emerged as a common and visible response (Leestma et al., 2025). Entities within both the public and private sectors, including educational institutions, can contribute by providing resources and logistical support for extensive cleanup efforts. Additionally, applying the cost of cleaning litter to tobacco products has been shown to be effective in reducing cigarette waste, according to audits conducted by cities (Leestma et al., 2025).

7.3 Reduction in Cigarette Consumption

While regulatory and educational efforts are essential, the most effective long-term strategy for addressing cigarette waste is to reduce cigarette consumption. Public health campaigns encouraging smoking cessation lead to a significant decrease in smoking behavior (Davis et al., 2022; General and Health, 2020; Riley et al., 2017) and this could reflect in a reduction of cigarette waste produced annually. In the United States, the number of former cigarette smokers now exceeds that of current smokers. Over the past decade, national surveillance data show modest progress, with about two-thirds of adult smokers wanting to quit, and slightly more than half attempting to do so each year (Babb et al., 2017).

Undertreatment is common among smokers using cessation aids, with relapse rates exceeding 50%, and most attempt to quit without any assistance. Unaided quitting probably remains frequent due to various factors, including the high percentage of tobacco users without health insurance and nearly 30% of adult cigarette smokers being uninsured, as well as the limited coverage of cessation treatments by both public and private insurance (DiGiulio et al., 2018). Government-funded initiatives are needed to ramp up resources, such as counseling, nicotine replacement therapies, and quit lines, which can provide support for individuals trying to quit smoking. By reducing the number of people who are involved in smoking, the amount of cigarette waste that is released into the environment is reduced.

7.4 Investing in Cigarette Waste Recycling and Reuse

To mitigate the environmental impact of cigarette butts, substantial investment in waste recycling and reuse technologies is needed. Developing new recycling methods could lead to more sustainable waste management solutions. An encouraging area of innovation may be repurposing cigarette butts as raw materials for products such as insulation and construction materials. Several studies in the literature have shown that recycling cigarette waste can serve many purposes. Dieng et al showed that toxic substances can disrupt the development of insecticide-resistant mosquitoes (Dieng et al., 2013). The combination of nicotine and silver nanoparticles has been demonstrated to decrease egg hatchability and larval activity in *Anopheles stephensi*. Furthermore, adding nicotine to lethal traps has been shown to suppress dengue vector populations (Shah et al., 2023a). Exposure to cigarette butts can influence the egg-laying, hatching, and development of *Aedes albopictus* and *Aedes aegypti*, both of which transmit dengue fever (Dieng et al., 2011).

Cigarette waste has applications in the production of functional carbon, which is used for supercapacitor electrodes (Li et al., 2020). This solves an environmental problem and offers a potential renewable energy source. Activated carbon is also widely used in various industries for storage, purification, disinfection, separation, and absorption. The traditional raw materials, like coal and coconut shells, for producing activated charcoal, are expensive and difficult to regenerate (Mizan, 2022).

Cigarette butts also have applications in construction. Various studies have shown that cigarette butts can be used as an ingredient in gypsum compounds (Romero-Gómez et al., 2022) which gives it better enhancements in mechanical strength (Aguilera Benito et al., 2023). Cigarette waste has also been shown to be used in producing fired clay bricks (Kurmus and Mohajerani, 2020; Mohajerani et al., 2016). The fire brick industry is facing a challenge in producing energy-efficient bricks at a low production cost, yet with a higher insulation ability (Shah et al., 2023b).

Cigarette butts have applications in being used as acoustic attenuators for absorbing noise, with urbanization and industrialization on the increase (Thompson et al., 2022). Cigarette butts have distinct chemicals that are acoustic absorbers (Matos et al., 2017). Cigarette butts are porous in nature, and they easily absorb acoustics. (del Rey et al., 2017). Additionally, adding cigarette waste to asphalt concrete, which is used in paving roads, has been shown to reduce the need for natural aggregates and improve their performance (Abbas et al., 2017).

Some chemicals in cigarette waste, like nicotine, have anticorrosive properties and have been found useful in the petroleum industry in preventing corrosion in industrial equipment, which causes \$1.372 billion in damages (Shah et al., 2023b). Research has been able to show that cigarette waste is able to reduce corrosion on steels that are exposed to acids, and the anticorrosive effects increase with increasing concentrations of cigarette butts (Lucatero et al., 2016).

Potassium carbonate-activated carbon derived from cigarette waste has proven effective at removing chloramphenicol and other antibiotics. This has applications in clinical areas where using antibiotics can cause antibiotic-resistant diseases (Ahmed et al., 2024).

In various industries, including paper, cosmetics, biomedicine, textiles, and linens, cellulose is a crucial component. Its primary source is plants, and harvesting plants affects biodiversity. Efforts are underway to explore alternative cellulose sources to decrease reliance on plant materials and promote sustainability (Kargarzadeh et al., 2018). Cigarette filters contain millions of non-degradable cellulose acetate fibers, which contribute to environmental waste every year (Shen et al., 2021a). As a result, emerging research is trying to convert cigarette waste into a cheap source of cellulose (d’Heni Teixeira et al., 2017a). This is a renewable and environmentally friendly option, but it has not been adopted widely because cigarette waste may contain toxic substances (d’Heni Teixeira et al., 2017b).

Hydrogen has recently gained prominence as an energy source due to its minimal production of carbon dioxide as a waste byproduct. Adequate hydrogen storage requires a material with a high surface area, which can be achieved via physisorption. Because of this, researchers are using activated carbon for hydrogen storage due to its elevated activation temperature, extensive surface area, and porosity (Scott Blankenship and Mokaya, 2017).

7.5 Environmental Justice and Equity

Cigarette waste is a visible yet often overlooked environmental justice concern that brings to light systemic inequalities in environmental exposure, regulatory protections, and public health impacts. (Beard et al., 2024; Lowe et al., 2024b). Cigarette butts are the most frequently discarded solid waste worldwide (Stigler Granados et al., 2019). Although cigarette consumption covers all socioeconomic levels, the environmental and health repercussions of cigarette waste disproportionately affect communities with limited political influence, inadequate waste management infrastructure, and heightened baseline exposure to environmental hazards.

Low-income neighborhoods, marginalized racial and ethnic communities, and densely populated urban areas often have more cigarette litter (Lowe et al., 2024b). A higher concentration of tobacco retailers drives this, targeted marketing efforts, weaker enforcement of litter laws, and limited municipal cleanup resources (Ackerman et al., 2017). As a result of this, cigarette waste becomes embedded in sidewalks, storm drains, playgrounds, and waterways, raising exposure risks for children and vulnerable groups. This uneven distribution of environmental contamination shows systemic inequalities rather than individual behaviors, positioning cigarette waste as a significant environmental justice issue.

Environmental exposure pathways exacerbate preexisting inequalities. Cigarette butts can be carried by stormwater into rivers, lakes, and coastal zones, leading to aquatic toxicity and microplastic pollution (Shen et al., 2021b). Communities downstream of urban centers or near poorly managed waterways face greater exposure to contaminated water and sediment, often with limited monitoring or cleanup (Shen et al., 2021c). In coastal and informal settlements without proper waste infrastructure, cigarette waste accumulates alongside other pollutants, increasing the overall exposure risks (Araújo and Costa, 2019c).

Cigarette waste is a health danger for smokers and for the broader community. Children in low-income neighborhoods are more often exposed to cigarette butts in homes and parks, increasing concerns about accidental swallowing and skin contact with toxic residues. Workers engaged in cleanup efforts, informal waste pickers, and sanitation staff face risks during trash collection and manual removal, often without adequate protective equipment (Leite Magalhães et al., 2021; Ngwira et al., 2024). These exposure risks deepen social vulnerabilities, emphasizing persistent problems of environmental and occupational injustice.

Policy and regulatory shortcomings worsen existing inequalities. Tobacco products are frequently regulated so that cigarette filters are treated as consumer litter rather than hazardous waste, shifting cleanup costs onto local governments and taxpayers (Curtis et al., 2017). This externalization primarily affects resource-constrained communities that lack the funds for waste management. Furthermore, the minimal application of extended producer responsibility policies allows the tobacco industry to evade accountability for the environmental harm it causes further along the supply chain, thereby perpetuating an unfair distribution of costs and risks (Curtis et al., 2017).

The process of addressing cigarette waste through an environmental justice lens requires moving the focus from personal littering to systemic accountability and environmental rights. Equity-focused strategies involve holding producers responsible, restricting single-use cigarette filters, enhancing waste management infrastructure in underserved communities, and including cigarette waste in environmental and public health tracking. Without these actions, cigarette waste will persist as a visible and damaging reminder of unequal environmental protections.

Recognizing cigarette waste as an environmental justice concern emphasizes the importance of integrating tobacco control measures, environmental policies, and public health initiatives. Protecting communities from the environmental

harm resulting from tobacco products pertains to safeguarding social equity and upholding the environmental rights of all individuals.

8 CONCLUSION

Cigarette waste remains a significant yet often overlooked issue. Despite progress in tobacco control reducing smoking rates, the environmental and health risks of discarded cigarette butts are still largely ignored. These wastes release toxic chemicals and can be ingested by children and animals, creating complex environmental, health, and social justice problems. The lack of strict regulations and industry accountability allows this problem to persist quietly. However, approaches such as extended producer responsibility, banning non-biodegradable filters, raising public awareness, and incorporating waste reduction into public health policies are adaptable solutions. Cigarettes are environmental pollutants with long-term impacts, and tackling this neglected issue is essential for building cleaner, healthier, and more equitable communities.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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