

SYNTHESIS

Smoke-Free Series: Post-Consumer Waste of Tobacco and Vaping Products

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Research Question

What is the effectiveness of environmental strategies and policies to protect people from the environmental impact of waste from tobacco, heated tobacco products, vaping, and cannabis products and by-products?

Key Messages

- One systematic review, five narrative reviews and four primary studies were included in this document on post-consumer waste of tobacco, e-cigarettes, heated tobacco and cannabis products and by-products. No additional relevant primary studies or reviews were located in the October 2023 updated search results. Papers cited within the findings section are all found as a result of the original searches conducted in November 2019.
- Nicotine itself is toxic hazardous waste, and among tobacco products, cigarette butts constitute the largest amount of waste and are considered environmental hazards.^{1,2}
- Vaping products are considered hazardous waste generators, with a range of compounds and chemical content. Among disposable vaping products, lead content varies among manufacturers.¹ One study showed that lead exceeded regulatory threshold for two out of the 15 products tested.³ Now that schools and other settings confiscate or have to clean up vape product discards, they have to treat all such products as hazardous waste disposal.^{1,3}
- E-liquid and vaping cartridges did not significantly decrease growth of microorganisms and therefore appear to not pose a threat to the microbiological environment; however, ecotoxic effect may depend on flavour additives used in e-liquid production.⁴
- Metabolites of cannabis have been detected in samples of untreated and treated wastewater, surface water, and tap water in Europe, Asia, Latin America, and North America.⁵ These metabolites have shown to cause oxidative stress in aquatic species.⁵
- To reduce the impact of cigarette waste on the environment, a number of interventions have been suggested, such as: a waste fee,^{2,6,7} fines for littering,⁷ deposit/return of cigarette butts,⁷ smoking ban in public places (including beaches),⁶ beach cleanup,⁶ warning labels about the non-biodegradability and toxicity of cigarette butts,⁷ biodegradable cigarette filters,^{2,7} education,^{2,7} and recycling.⁸

- While waste mitigation measures play a role, it is important to emphasize upstream approaches. Examples include banning the sale of filtered cigarettes, vaping products, filters, and heated tobacco products altogether. Alternatively, make their cost and regulatory structures match that of the ecosystem damage.⁹
- These findings add to the evidence base regarding the impacts of post-consumption cigarette waste summarized by the SFO-SAC (2016) report. The current evidence is consistent with the SFO-SAC (2016) report in suggesting that cigarette butts and vaping products, if improperly disposed of could be harmful to the natural environment, as well as to human and animal health.

Background

There is increasing research and public awareness of the environmental impacts of tobacco, heated tobacco, vaping and cannabis products.^{5,10-13} The Environmental Protection Agency (EPA) has listed nicotine (including nicotine salt) as an acute hazardous waste.¹

Post-consumer waste describes what is left over after a product has been used (e.g., cigarette butts, vaping cartridges). Cigarettes butts are considered the most common form of personal litter on beach and urban clean-ups in the world and have been for decades.^{6,14} Cigarette butts remain the most found litter item on Canada's freshwater and marine shorelines.¹⁵ Environment and Climate Change Canada have identified cigarette butts/filters as prevalent in the environment (natural and/or urban) with a known or suspected environmental harm.¹⁶ Cigarette butts are comprised mainly of a cellulose acetate (plastic) filter.^{7,14,17} The filter in cigarette butts contain a great number of harmful chemicals that leach into the environment; the plastic filter and chemicals remain in the environment for many years.^{7,14,17} Littering of cigarette butts is identified as a threat to urban water and potentially drinking water.^{18,19}

The rise in vaping product use compounds the impacts on the environment, with many popular vaping products being pod-based with single-use plastic cartridges as well as the emergence of disposable vaping products that are designed entirely for one-time use. This changes the composition of the environmental harms of tobacco and nicotine products. Heated tobacco products are distinct from vaping products, as they contain tobacco, use actual heated leaf to deliver nicotine, instead of solutions of nicotine. The full environmental impact of both of these products is unclear. There are several basic components to vaping devices, regardless of which generation, there are several environmental impacts from their inappropriate disposal or littering.^{12,20}

With the recent legalization of non-medical use of cannabis in North America, there is growing interest in the impact to on the environment. Most recently, detection and occurrence of cannabis and its metabolites in the aquatic environment.^{5,13} There is a need to develop a fast, selective, and sensitive analytical method to detect such compounds to understand their fate, transport and behaviour in surface water and wastewater, and determine any harms to the environment and also flow-on impacts with subsequent drinking water consumption.^{5,13}

Thirdhand smoke refers to tobacco residue from cigarettes, cigars and other combustible tobacco products that lingers in an environment where smoking has occurred.²¹ Thirdhand smoke settles in dust, is absorbed by surfaces (e.g., carpeting, upholstery, paneling and drywall), and is carried on the hair, skin, fingernails and clothing of smokers.^{22,23} It can also combine and react with oxidants and other compounds in the environment (e.g., ozone and nitrous acid) to create new compounds, many of which are carcinogenic and are persistent and difficult to eliminate.^{24,25}

Evidence from the Smoke-Free Ontario Scientific Advisory Committee 2016 (SFO-SAC 2016) report²⁶ noted that cigarette butts harm the environment by leaching toxic chemicals into water systems and can harm animals and small children if ingested. Other tobacco products, such as shisha and vaping products, also have negative environmental impacts if not disposed of properly; toxic elements from waterpipe waste water can enter the water system, and toxic elements can leach from vaping product batteries.

Methods

A peer-reviewed literature search was conducted on November 26, 2019 by Public Health Ontario (PHO) Library Services for articles published between 2015 and 2019. The search did not extend earlier than 2015 because a comprehensive summary of evidence on this research question had been completed (see the Protection Chapter in the Smoke-Free Ontario Scientific Advisory Committee 2016 (SFO-SAC 2016)).²⁶ An update to the search was conducted October 20, 2023 by PHO Library Services. The update used the same search strategy, with minor search vocabulary adjustments due to changes in database vocabulary over time (e.g., the addition of subject headings such as “Vaping” in CINAHL, and "ELECTRONIC waste" in Environment Complete).

The search involved four databases, including MEDLINE (Ovid), Embase (Ovid), CINAHL (EBSCO) and Environment Complete (EBSCO). The following search terms were included, but were not limited to: electronic waste, hazardous waste, butts, by-product, batteries, cartridge, filters, recycling, thirdhand smoke, environmental health, and water pollutants. The full search strategy is available upon request from PHO.

In the original search, articles were eligible for inclusion if they were review-level articles, published between 2015 and 2019 and included interventions and/or policies on post-consumption waste generated from tobacco, e-cigarette, and cannabis products and by-products, or decontamination of thirdhand smoke, or described the impact of tobacco, e-cigarette, and cannabis products and byproducts on the environment (i.e., on the water system). The updated search included primary studies as well, in order to capture study-level evidence related to the inclusion criteria. Articles that did not include interventions, policies, or describe the environmental impacts of tobacco, e-cigarette, and cannabis products and by-products were excluded. Editorials, conference abstracts, protocols, and articles from non-OECD countries were also excluded. The same screening criteria for inclusion were used in both the original search and the update.

One reviewer screened titles and abstracts, and two reviewers screened full-text versions of all articles considered for inclusion. For all relevant papers, one PHO staff extracted relevant data and summarized content.

Quality appraisal was conducted for each included review using the [Healthevidence.org](https://www.healthevidence.org/) Quality Assessment Tool for Review Articles.²⁷ Two reviewers made independent assessments for each of the 10 quality criteria. Any discrepancies were resolved by discussion. Quality appraisal was not applicable to the update since no new relevant results were available to appraise.

Findings

The original literature search identified 600 articles, of which 10 met inclusion criteria. The updated literature search resulted in an additional 686 articles being screened, of which none met inclusion criteria. One paper was a systematic review,² five were narrative reviews,^{5-8,12} and four were primary studies.^{3,4,28,29} The six reviews were appraised as weak.^{2,5-8,12} Jurisdictions of the included studies within reviews covered the entire globe where cigarette and cannabis product waste are littered and one review focused on coastal environments,⁶ while another review focused on aquatic environments.⁵ Jurisdiction of primary studies included Poland, United States, and the United Kingdom. The literature is organised and described by product type. To provide real world examples, a few of the evidence descriptions have additional websites noted. No additional relevant primary studies or reviews were located in the updated search results, and so no changes have been made to the findings as a result of the October 2023 update.

Tobacco Products

- Five reviews and two primary studies focused on the impact of waste from cigarettes on the environment.
- Cigarette butts constitute the largest amount of waste among tobacco products and among all waste in urban roads/streets and public places.² Cigarette butts are considered environmental hazards for aquatic organisms,²⁹ as well as having a direct poisoning effect on infants, domestic and wild animals due to ingestion.² This litter contains dangerous chemicals such as nicotine, heavy metals, PAHs (polycyclic aromatic hydrocarbons), PAC (polycyclic aromatic compounds), arsenic, benzene, hydrogen cyanide, pyridine, and ethylphenol.² Cigarette filters are also made from non-biodegradable materials (e.g., cellulose acetate, a plastic), therefore, cigarette butts remain in the environment for a long time.²
- A primary study by Baran et al. (2019), performed an experiment to investigate the effect of waste from cigarettes and heated tobacco products on aquatic microorganisms.⁴ They found heated tobacco products had a particular strong growth inhibitory effect on microorganisms, which suggests just one piece discarded into water could adversely affect the activity of the microorganisms living in the aquatic environment.⁴ Cigarette butts also had a high eco-toxicity on microorganisms, and since they contaminate the environment to the greatest extent, pose a significant threat to the aquatic environment.⁴
- There are number interventions that have been suggested to reduce the impact of cigarette waste on the environment; however, none of the reviews provided evidence of effectiveness of these interventions. Collecting cigarette butts is difficult due to their small size and high cost of collecting them.² Below are a list of strategies to reduce cigarette butts in the environment, identified from the included articles.
- Apply a waste fee (e.g., The San Francisco Cigarette Litter abatement fee)³⁰ to cigarette products to pay for specific programs (e.g., cleanup, communication, enforcement) and proper disposal of cigarette butts.^{2,6,7}
- Manufacturer's responsibility to take care of the post-consumer hazardous waste process;^{7,12} has been done before for other products, such as tire and acid-lead batteries, fluorescent lamps, paint, and insecticides.⁷
- Tobacco industries are strongly opposed to fees and taxation and extended producer responsibility (EPR) programs on their products.^{7,12} Tobacco industries consistently defend that the smoker is responsible for correctly discarding cigarette residues.⁶

- Fines for littering cigarette butts; money used to clean up cigarette butts.⁷
- Deposit/return of cigarette butts similar to the program for drinking bottles.⁷
- Smoking ban in public places (including beaches), studies have shown significant reduction of cigarette-related litter and in aquatic and coastal environments; success depends on available resources.⁶ Resistance from politicians and related groups who claim banning smoking in public places is a violation of individual rights and no more a source of cigarette butts on beaches than urban runoff.⁶
- Beach cleanup; usually done by hand or sometimes small mechanical vehicles.⁶ Not the most efficient method since cigarette butts are small and cleanup can be expensive. A study in another review found cigarette butts were still present on the beaches even after cleanup.² Previous approaches with relying on individuals who smoke to change their behaviour or relying on voluntary groups (e.g., Ocean Conservancy) to clean up have not been successful, with calls for the tobacco industry to take responsibility with product changes and financial compensation for cost of community clean-up.³¹
- Warning label about the non-biodegradability and toxicity of cigarette butts on its packet.⁷
- Produce biodegradable cigarette filters.^{2,7} This has the potential to lead to increased littering if smokers have less incentive to dispose of butts properly and do not know which filters are biodegradable.
- Portable ashtrays, especially at beaches.^{2,6} Efficacy remains questionable since not all cigarette butts were put in containers.⁶
- Education; raising awareness among individuals important for reducing littered cigarette butts because individual behaviours play a key role in the production of these wastes.^{2,7} Many organizations broadcast information on the hazards of cigarette butt littering on beaches and coastal environments to call attention to smokers and non-smokers.⁶
- Recycling cigarette butts.⁶⁻⁸
- The narrative review by Marinello et al. (2020) provides the most comprehensive list of recycling methods for cigarette butts.⁸ Categories in which recycling cigarette butts can be used for include: chemical analysis (e.g., mesoporous char), infrastructure/ buildings and structures (e.g., bricks and asphalt), energy storage devices (e.g., porous carbon structure), environmental engineering (e.g., biofilm carrier for waste water treatment), chemical and medical industries (e.g., nanocrystalline cellulose), insecticides, metallurgical industry (e.g., extract as corrosive inhibiting agent), and paper industry (e.g., cellulose pulp).⁸
- All of these methods have only been performed at a pilot scale and have yet to be performed at a larger scale.⁸
 - It is important to emphasize that the recycling idea is downstream. It will still require pickup or collection of cigarette butts (which is shown to be ineffective against the vast quantity discarded and would require a major infrastructure resource).^{2,6} It is important to emphasize upstream approaches, such as banning the sale of filtered cigarettes, filters, vaping products, and heated tobacco products altogether; or at least make their cost and regulatory structures match that of the ecosystem damage (e.g., ongoing effort in California).³²

Cannabis Products

- One narrative review by Park et al. (2017) summarized studies on the occurrence, detection, and treatment of the main psychoactive compound in cannabis, Δ 9-tetrahydrocannabinol (THC) and its metabolites in aquatic environments.⁵ Samples were taken from drinking water; tap water; wastewater; river water; lake water; surface water; ground water; wastewater treatment plant; drinking water treatment plant; wastewater influent; and wastewater effluent.⁵ Most of the samples came from Spain, but other jurisdictions included Switzerland, the Netherlands, Slovakia, the European Union, Japan, Latin America, Italy, Martinique, Greece, the United States, China, France, Belgium, Canada, Croatia, and the United Kingdom.⁵
 - Results showed that the main metabolite of THC, THC-COOH was detected in untreated and treated wastewater, surface water, and tap water.⁵ THC and THC-COOH have been shown to cause oxidative stress to aquatic species.⁵ There are currently no specific regulations regarding THC-COOH in drinking water or effluent wastewater.⁵ Very few published treatment studies have investigated the removal of THC-COOH from water.⁵ Methods such as chlorination and UV oxidation have led to potentially form by-products that would be toxic in aquatic environments.⁵

Vaping Products

- Two primary studies performed experiments on waste produced by vaping products, including e-liquids, substances leached from used vaping cartridges and disposable products.^{3,4}
- The study by Krause and Townsend (2015) examined the potential for disposal vaping products to be classified as hazardous waste. They analyzed a total of 23 samples of disposable vaping products, representing 15 unique products from eight national and regional manufacturers or distributors. Four products were selected for further testing.³
 - Results showed that two of the 15 products they tested exceeded the regulatory threshold for lead (US context). The samples leaching the three highest concentrations of lead were from the same manufacturer, which suggest that lead content varies among manufacturers of vaping products.³ None of the other hazardous metals surpassed their respective regulatory threshold.³
- The study by Baran et al. (2019) investigated the effect of substances leached from vaping cartridges and from e-liquids on microorganisms.⁴ In a laboratory setting, they assessed eight commercially available e-liquids for vaping products, used cartridges of various brands.⁴
 - Results showed that overall, e-liquid and vaping cartridges did not significantly decrease growth of microorganisms;⁴ however, there were significant differences in growth depending on the tested e-liquids.⁴ For example, the flavour Ice Mint e-liquid caused a 43 times higher sensitivity in one of the microorganisms. This suggests that the eco-toxic effect may depend on flavour additives used in e-liquid production.⁴

Decontamination of Thirdhand Smoke

One primary study was identified from the literature search. Cieślak et al. (2017) examined the ability of modified polypropylene (PP) fibre to reduce nicotine concentrations in the air. In a laboratory setting, they showed reduced nicotine levels.²⁸ To understand real world examples, the Thirdhand Smoke Resource Centre (thirdhandsmoke.org) has further research and resources about thirdhand smoke risks, mitigation and projects.

Limitations

Quality appraisal for the included primary studies was not possible, as there is no tool to specifically assess experimental studies at this time. The reviews retrieved by the original search (2019) were weak in quality primarily due to: a lack of information on inclusion criteria, no comprehensive search strategy reported, the search was less than the past five years and the studies were not assessed. The updated search in 2023 did not uncover any new, relevant results to address the question since 2019; thus, the limitations still apply.

There is limited research on addressing post-consumer waste from tobacco products. Discarded cigarette butts are a particularly difficult problem because they are small in size, have a widespread dispersion, and are costly to collect.² More research is needed on scaling up pilot projects on recycling cigarette butts to a larger scale. Additional research is also needed on interventions that address thirdhand smoke.

For emerging products such as heated tobacco, vaping products, and cannabis, there is limited information on the environmental harms and proper disposal for these products and their by-products. As novel tobacco, nicotine-containing, and cannabis products become more popular worldwide, more research is needed to assess the environmental impacts from the waste created by these products.

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