

Emerging tobacco pollution: Residual nicotine and other environmental toxicants in discarded "disposable" e-cigarettes and heated tobacco products

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INTRODUCTION

Cigarettes are one of the largest contributors to tobacco product waste (TPW) as approximately **4.5 trillion** cigarette filters are littered annually around the world [11]. Cigarette butts are the most collected litter items during the annual Ocean Conservancy's International Coastal Cleanup [6]. This is a problem because cigarette butts are slow-to-biodegrade, leach highly toxic chemicals in the environment, and adversely impact animals and humans [1, 3, 8, 10, 12].

In recent years, novel non-combustible smoking devices including electronic nicotine delivery systems (ENDS) and heated tobacco products (HTPs) have grown in popularity, marking novel potential environmental hazards. Very little is known about the long-term environmental impact of ENDS and HTPs. Using both targeted and non-targeted analyses, chemicals of concern in smoked, littered ENDS and HTP leachates were identified and compared to those of cigarette butts.



Figure 1. Diagram representing possible pathways for human exposure to TPW (adapted from: Novotny & Slaughter, 2014).

OBJECTIVE

Objective: Determine and compare the environmental and health effects of HTP and END products in post-consumption waste

<u>Aims:</u>

- 1. Identify chemical compounds present in the leachates of ENDS and HTPs post-consumption
- 2. Determine relative concentrations of nicotine and cotinine, major chemical components of tobacco products
- 3. Identify hazards of the compounds in the leachates



Figure 2. Image of a disposable ENDS (adapted from: Flum Pebble, 2020).



Figure 3. Image of a HTP (adapted from: Plain, 2019).

METHODS

Leachate samples

- **ENDS** collected in San Francisco area (n=3)
- **HTPs** collected in Osaka and Kobe, Japan (n=9)
- **Cigarette butts** machine smoked (n=2)
- Nicotine and cotinine analysis
- Quick-Easy-Cheap-Effective-Rugged-Safe (**QuEChERS**) technique for sample preparation
- Analysis via LC/MS/MS
- Nontargeted analysis (NTA)
- Solid-phase extraction for sample preparation
- Analysis via GCxGC/TOF-MS to determine chemical profiles of HTP and END leachates
- Use "Statistical Compare" feature in ChromaTOF to automatically align peaks (S/N \gtrsim 50)
- Export results to Excel to manually review criteria • Organized into 8 subgroups, comparing ENDS/HTPs to cigarette butt leachates
- **Compound prioritization by hazard**
- Rank tentatively identified chemicals according to hazard profiles in U.S. EPA Cheminformatics Hazard Comparison Module using average hazard scores [4]
- Sum abundance-adjusted composite hazard scores to compare hazards of product leachates

RESULTS - NTA

• 295 unique compounds tentatively identified 117 previously identified in tobacco and/or tobacco smoke [9]

GLO-NPBB GLO-KM GLO-KR IQ-RTN -1 -IQ-MTG IQ-RTLB -2 -PLO-R -3 -MIIX-M -4 PLO-M MAR-R -5 -MAR-M -6 FLUM-P ELF-B FLUM-F Compound

Figure 6. Heatmap produced of chemicals tentatively identified in HTPs, ENDS, and cigarette butts

Table 1.	Summary of compounds identified in 8 subgroups	S.

ENDS Versus Cigarettes	Unique to ENDS	Unique to Cigarettes	Abundant in ENDS	Abundant in Cigarettes
eigarettee	46	118	34	51
HTPs Versus Cigarettes	Unique to HTPs	Unique to Cigarettes	Abundant in HTPs	Abundant in Cigarettes
	41	8	22	196

Table 2. Sum of weighted scores of tobacco product leachates by subgroup

Sum of Weighted Composite Scores for Compounds in Product Leachates							
ENDS vs Cigarette Butts		HTPs vs Cigarette Butts					
ENDS	Cigarette butts	HTPs	Cigarette butts				
4.65	4.51	4.18	4.41				

Figure 4. Diagram of leachate preparation. Two used butts were placed in 1 L egg water with a magnetic stir bar left on for 24 hours. After, the leachates were filtered through 0.7 µm Whatman filter paper.



instrumentation.



Figure 5. Image of GC×GC/TOF-MS









Figure 8. Bar chart of cotinine concentrations averaged from three 1 mL samples of leachates log-transformed.

FINDINGS

NTA

- Peak clustering by product type and brand
- Greatest chemical overlap between cigarette butt and HTP leachates Nicotine
- Highest concentration leached from ENDS, lowest from HTPs
- Menthol-flavored HTPs leached more nicotine than same-brand regular flavored HTPs

Cotinine

- Highest concentrations in cigarette butt leachates, lowest in HTPs
- Menthol-flavored HTPs leached more cotinine than same-brand regular flavored HTPs (except Glo)
- **Compound prioritization by hazard**
- ENDS leachates more hazardous than cigarette butt leachates
- Cigarette butt leachates more hazardous than HTP leachates

ACKNOWLEDGEMENTS

This project was supported by the California Tobacco Related Disease Research Program (T32IP5382) and Hopper Diversity Supplement (T33IR6723S).

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Menthol Regular Menthol Regular Purple Menthol Regular Menthol Regular Water FB Average Cotinine Concentrations Log10 Transformed (n=3) (ng/mL) comparison approaches to support prioritization of unregulated organic contaminants in biosolids. Environmental Science & Technology, 58(27), 121 35-12146.