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No "Butts" About It: The Heavy Metal Impact of Cigarette Litter

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Introduction:

Cigarettes are the most common litter globally (Joly, 2017; Poppendieck, 2020; Michael, 2022). Following smoking, the filter is left with carcinogenetic compounds, tar and metals (Joly et al. 2011), all of which are highly toxic for wildlife, affecting reproduction, behavior and mortality rate in animals (Green et al. 2022; Dieng et al. 2013). The heavy metals that are left within the filter also have potential to leach from the cigarettes and enter the groundwater system (Akhbarizadeh et al. 2021). As these heavy metals enter the system, it leads to adverse effects of environment and can cause detrimental health effects in humans, such as cell damage, induced carcinogenic processes and loss of cellular functions (Engwa et al. 2019).

Objective:

Our objective was to determine the amount of heavy metals entering the Macatawa Watershed via cigarette butt litter.

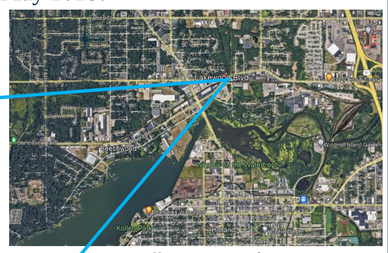
Methods:

Collection 1: Freshly-smoked cigarettes were collected from a cigarette receptacle in downtown Holland and separated into two groups; a control and rainwater simulation group. The leaching process was simulated by putting ten freshly collected cigarettes in a rotary shaker for 24 hours. Cigarettes were submerged in an artificial rainwater solution with a pH of 5.68. This was Holland's average rainwater pH in 2022.

Before simulation

After simulation

Collection 2: 300m stretch of Lakewood Blvd, including residential, commercial, and industrial buildings. A total of 399 cigarettes were collected on both sides of the road. This occurred 177 days after an initial litter collection was completed on this site in May 2023.



Map 1. Collection site of Lakewood Boulevard,

Cigarettes collected on Lakewood Blvd

Ten cigarettes from each sample group were placed into a MARS 6 microwave digestor to identify and measure the concentrations of heavy metals present within the cigarettes.

Results:

From the tests, iron yielded the highest concentration of metals tested, followed by aluminum and magnesium. Within the trace metals sampled, zinc yielded the highest concentration.

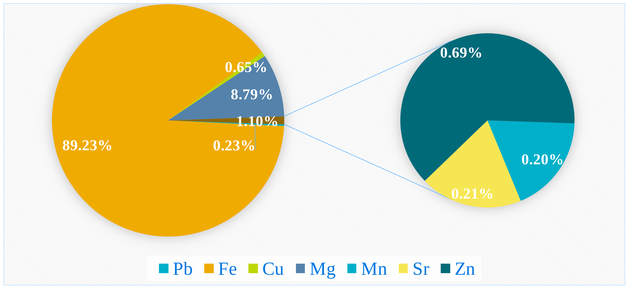


Figure 1: The pie chart above describes the relationship between each heavy metal tested relative to the total concentration. Fe is the highest concentration detected, followed by Mg and Al, seen in left pie chart. The chart on the right details the spread of the trace metals tested within the larger chart on the left, in which Zn is the highest trace metal detected.

	Pb	Fe	Al	Cu	Mg	Mn	Sr	Zn
Lab	8.7	3249.9	155.1	17.9	280.68	7.676	8.705	78.8
Unexposed	7.15	2796.6	204.67	20.4	275.4	6.29	6.5696	21.68
Road Side	6.78	2876.81	370.95	21.3	286.3	8.41	7.55	29.7

Figure 2: Table detailing the concentrations of heavy metals within the three samples. The highest concentration of each heavy metal is highlighted in yellow. Units are in µg metal per gram of cigarette.

Acknowledgements
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Calculating Flux:

Flux is the amount of material moved from one reservoir into another over a specific time period (Li et al. 2012). In this case, we calculated the flux of metals moving from cigarettes butts into the Macatawa watershed. An estimate was made with the sample results to determine the amount of heavy metals leaching into the Macatawa Watershed from the 300m strip of land sampled. Units are in µg of metal per day.

Iron (Fe): 1297 µg Fe/day
Aluminum (Al): 167.24 µg Al/day
Magnesium (Mg): 129.08 µg Mg/day
Zinc (Zn): 13.39 µg Zn/day
Copper (Cu): 9.60 µg Cu/day
Manganese (Mn): 3.79 µg Mn/day
Strontium (Sr): 3.40 µg Sr/day
Lead (Pb): 3.06 µg Pb/day

Discussion:

Our results indicated the presence of heavy metals within the samples tested. Cigarette butts break down at various rates, ranging between 18 months and 10 years for full decomposition. However, their eventual breakdown is inevitable. This scale is referring to the physical structure of a discarded cigarette, not necessarily the materials contained within. It is a possibility that the metals within the filter leach quicker than this, but it is inconclusive as of now. The materials within the cigarette transfers into the surrounding environment as the cigarette breaks down, resulting in the leaching of its components, including the metals detected in our tests. As the metals leach from discarded butts, they enter the groundwater, polluting the local environment, animals, and even people.

Future Directions:

Standardization of Samples:

Analysis of more un-leached samples "smoked" through a standardized laboratory method rather than relying on local cigarette receptacles would increase the precision of metal content in the fresh samples.

Creating an Accurate Model of Cigarette Butt Decay:

Based on the data we collected, the leaching of heavy metals from littered cigarette butts on roadsides cannot only be explained via rainwater. Identification of other factors relevant to the breakdown of cigarette butt litter would allow us to add them to our model and test future samples via these improved methods.

Representative Collection:

The cigarette butt litter we collected was only from a 300-meter section of mixed-use main road in Holland. Collection from other surface streets (urban, suburban, and rural) would help with future analyses.

Citations

Comparison of Cellulose vs. Plastic Cigarette Filter Decomposition under Distinct Disposal Environments.
Https://Books.Google.Com/Books?Hl=en&lr=&id=nzj8DwAAQBAJ&oi=fnd&pg=PA77&dq=effects+of+various+heavy+metals+on+humans&ots=RBPQWzjbeR&sig=iOzIcrUKAC-WfJODR2n2I3rUcZg#v=onepage&q&f=false.
Https://Www.Scholarshipsinindia.Com/Answer/PH_of_rainwater.Html.
Https://Www.Sciencedirect.Com/Topics/Chemistry/Biogeochemical-Cycle#:~:Text=The%20reservoir%20is%20the%20amount,To%20the%20atmosphere%20by%20evaporation.
Influence of Temperature, Relative Humidity, and Water Saturation on Airborne Emissions from Cigarette Butts. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8077228/.
Leachate Analysis of Heavy Metals in Cigarette Butts and Bricks Incorporated with Cigarette Butts.
METHOD 3051A ASSISTED ACID DIGESTION OF SEDIMENTS, SLUDGES, SOILS, AND OILS.
Potentially Toxic Elements Leachates from Cigarette Butts into Different Types of Water: A Threat for Aquatic Environments and Ecosystems?
The Content of Heavy Metals in Cigarettes and the Impact of Their Leachates on the Aquatic Ecosystem.
The Ecological Impacts of Discarded Cigarette Butts.
Degradation of Cellulose Acetate-Based Materials: A Review.
Http://www.longwood.edu/cleanva/cigbuttbiodegradable.htm#:~:text=So%20how%20long%20do%20cigarette,time%20after%20they%20are%20discarded.