Emissions Analysis for Medical Waste Incinerator in Developing Communities

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Introduction & Design

In many developing communities, waste management presents a significant challenge, often relying on methods such as open pit burning or mixed waste disposal, which can have detrimental effects on both the environment and public health. This research is dedicated to address this pressing issue by evaluating the emissions of a masonry biomedical waste incinerator, designed to mitigate the adverse impacts associated with traditional waste disposal methods. Developed by a previous team from Lipscomb University, this incinerator utilizes dry wood as fuel and is based on a rocket stove design, utilizing turbulent airflow to increase air temperature. A key feature of this design is its feasibility for construction by local masonry workers using readily available and affordable materials.

Figure 1: Open pit burning at Beersheba Springs Medical Clinic

Figure 2: Prototype Constructed in Beersheba Springs, TN

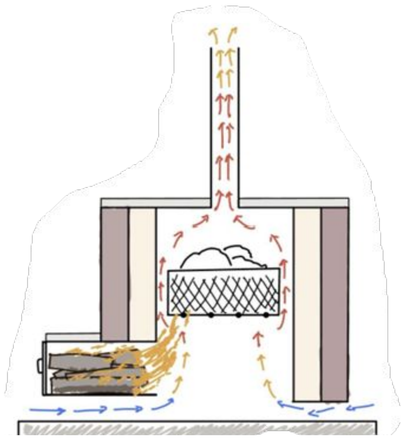


Figure 3: Cross-section view of incinerator design

Testing & Analysis

Method 9

Worst Case Scenario (high plastic concentration)

Figure 6: Biology lab waste used in worst case scenario test

Figure 7: Fuel for waste case scenario

Table 1: Weight recordings of waste and fuel for worst case scenario

	Fuel	Waste	total
		lb	
Preliminary	18.35	2.07	20.42
Test	39	10.92	49.92

Figure 8: Flue Opacity for Worst Case Scenario

Alternative Scenario (common waste composition)

Figure 9: Common waste used in alternative scenario test

Figure 10: Fuel for alternative scenario

Table 2: Weight recordings of waste and fuel alternative scenario

	Fuel	Waste	total
		lb	
Preliminary	45.44	0	45.44
Test	45.47	6.12	51.59

Figure 11: Opacity for Alternative Scenario

EPA WebFire Emission Factors (EF)

Primary Concerns

Wood Fire EF:
SCC - 50200201

- Particulate Matter
- Carbon Monoxide

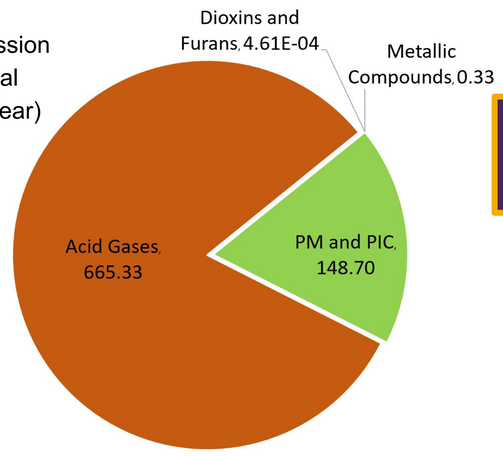
Waste Incinerator EF:
SCC - 50200501

- Metallic Compounds
- Dioxins and Furans

To combine emission factors to estimate amount of pollutants released annually…

- Medical Waste incinerated annually -- **3.12 tonnes/yr**
- Wood used for fueling incinerator annually -- **3.7 tonnes/year**

Figure 12: Annual Emission Distribution of Medical Waste Incinerator (lb/year)



Methods

Method 9

Method 9, is a EPA-established visual determination technique to assess the opacity, or visible emissions, emitted from stationary sources. In comparing Method 9 evaluations between a worst-case scenario with a high plastic concentration and a alternative scenario involving common waste, distinct differences in emission characteristics and opacity levels may result. The worst-case scenario, with its elevated plastic content, led to higher opacity and hazardous emissions. On the other hand, the alternative scenario, involving common waste, has low opacity levels and less pollutants. By comparing these scenarios, insights were gained regarding the effectiveness of waste management practices, the influence of waste composition on emissions, and the potential for reducing environmental concerns associated with waste combustion.

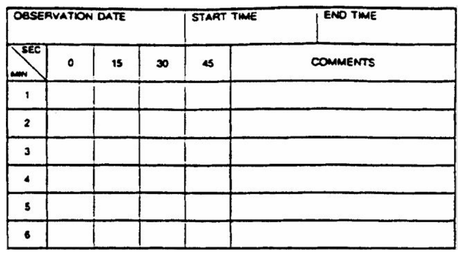


Figure 4: Method 9 Opacity Recording Form

EPA WebFire Database

The EPA WebFire Database provides access to emissions factors for various air pollution sources, including industrial processes, combustion devices, and other emission sources. Emission factors are numerical values that relate the quantity of a pollutant emitted to a unit of activity associated with the emission source. These factors are essential for estimating air emissions from various sources, conducting air quality modeling, and assessing compliance with air quality regulations.

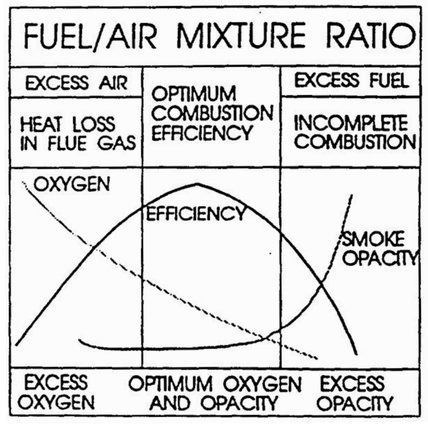


Figure 5: Correlation between smoke opacity and combustion efficiency

Results & Conclusion

Method 9 performed with high plastic concentration and common waste composition

- In the worst-case scenario (**81% opacity**), high opacity and hazardous emissions were observed, highlighting environmental concerns involved with improper waste management and incomplete combustion of waste.
- The alternative scenario (**2% opacity**) demonstrated low opacity levels and few pollutants, reinforcing the benefits of proper waste management and complete combustion with excess air.

EPA WebFire EF for Wood Fire and Waste Incinerator

- Utilizing the EPA WebFire Database provided rough estimates for pollutants released by both the incinerator and open wood fire, offering insight into the environmental impact of this process showing that acidic gasses and particulate matter are primary pollutants.

Future Work

1) Explore design modifications, such as relocating the firebox underneath the waste chamber, to optimize combustion efficiency and provide direct flame contact with waste material.
2) Use the ideal gas law for calculating emissions from the incinerator for comparison with regulatory standard **40 CFR 62 Subpart HHH** pertaining to **Small Rural Waste Incinerators.**

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1) "Method 9 -Visual Determination of the Opacity of Emissions From Stationary Sources." https://www.epa.gov/sites/default/files/2017-08/documents/method_9.pdf
2) "Welcome to WebFIRE," US EPA WebFire Online Database, https://cfpub.epa.gov/webfire/.