Monitoring and Modeling to Estimate Impact Of Hydrogen Sulfide Emissions and Dispersion Near Gas Wellheads On a Florida Class I Landfill

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Abstract

- According to the Bureau of Labor Statistics (BLS), H_2S (Hydrogen Sulfide) gas is one of the principal causes of workplace inhalation death.
- Similar studies have revealed that one of the principal sources of H_2S to the atmosphere is landfill activity, and in particular, gas wellheads (Skrtic, 2006).

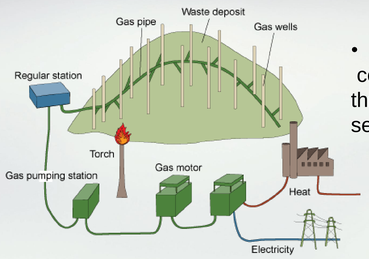
Background

MSW Collection and Transport

- In 2013, Americans generated about 254 million tons of trash and recycled and composted material amounted to about 87 million tons of this material, equivalent to a 34.3 percent recycling rate.
- Residential and commercial MSW is sorted by haulers and can be taken to a transfer station or directly to a landfill site.

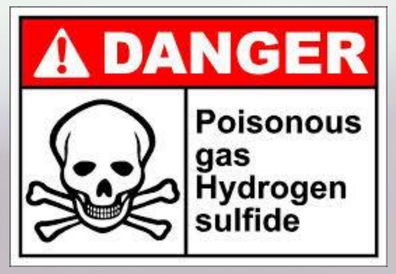
Class I Landfill

- There are approximately 61 Class I landfills in Florida that receive anywhere from 15 tons to as much as 10,000 tons per day.
- MSW is buried in cells and the Class I landfill selected for this study contains a gas collection system for its waste.



Landfill With Gas Collection System

- . Because an installed gas wellfield collection system is often evenly distributed throughout the cells of a landfill, H_2S can seep through the surface.
- Landfill gas has a typical composition of roughly 45-60% methane CH4, 40-60% carbon dioxide CO2 and approximately 0-1% hydrogen sulfide H2S.



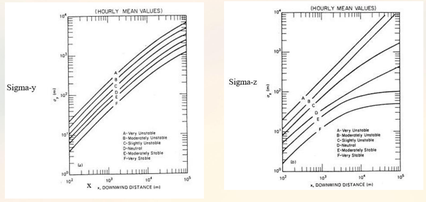
Hydrogen Sulfide Gas

- Although this study did not focus on odors, hydrogen sulfide has a characteristic foul odor of rotten eggs. British biochemist John E. Amoore stated that the true detectable limit of hydrogen sulfide lies Between 5 and 12 ppb (Amoore, 1985).
- At lower concentrations from 2 to 5 ppm, hydrogen sulfide can cause eye irritation, nausea and dizziness.

Objective

- The purpose of this study is to gauge the effect of age of landfill gas wellheads on ambient H_2S concentrations.

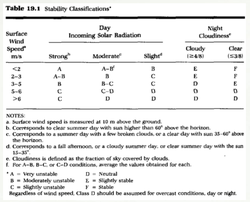
Materials and Methods



Gaussian Plume Vertical and Horizontal Coefficient Chart

Hydrogen Sulfide Analyzer

Landfill Gas Wellhead

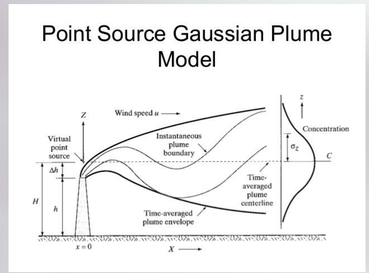


Stability Classification Chart

Kestrel Pocket Weather Meter

$$c(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left(\frac{-y^2}{2\sigma_y^2}\right)\left(\exp\left(\frac{-(z-h)^2}{2\sigma_z^2}\right)+\exp\left(\frac{-(z+h)^2}{2\sigma_z^2}\right)\right),$$

Gaussian Plume Formula



Gaussian Plume Model

Phase I

Phase I will involve establishing the detectable distances from each gas wellhead that the Jerome Hydrogen Sulfide Gas Analyzer can read

Phase II

Phase II of this study will involve choosing the main target sections of the local landfill.

Phase III

Phase III will involve selecting twenty representative gas wellheads of various ages; each well will be differentiated by the date of installation.

Phase IV

Phase IV will involve recording meteorological conditions (wind speed, wind direction, temperature, humidity, and altitude) with the Kestrel 3500 weather meter and hydrogen sulfide concentrations with the Jerome Hydrogen Sulfide Analyzer.

Phase V

Phase V of this study involves using Gaussian plume variables, meteorological conditions and hydrogen sulfide concentration data to calculate and plot the emission rate of the three bins.

Results

- It is anticipated that gas wellheads in bin 3 (youngest) will have the highest emission rates of ambient hydrogen sulfide.
- Another expected outcome for this study is that changing atmospheric conditions (clear, sunny, cloudy, overcast) and meteorological conditions (wind speed, wind direction, temperature, humidity, and altitude) will have the greatest effect on the monthly hydrogen sulfide gas concentration data.

Date	Milestone
March 15 - April 15	Instrument training. Preliminary study to determine the appropriate distance range for detection.
April 15 – May 15	Establish the Phases (sections) in the landfill that will be studied.
May 15 – June 15	Collect Data for Bin I (2 Gas Wellheads) Select gas wellhead for Bin III (1 Gas Wellhead)
June 15 – July 15	Collect Data for Bin I (2 Gas Wellheads) Select gas wellhead for Bin III (1 Gas Wellhead)
July 15 – August 15	Collect Data for Bin I (2 Gas Wellheads) (6 total Group III gas wellheads) Select Gas wellhead for Bin III (1 Gas Wellhead)
August 15 – September 15	Collect Data for Bin II (3 Gas Wellheads) Select Gas wellhead for Bin III (1 Gas Wellhead)
September 15 – October 15	Collect Data for Bin II (3 Gas Wellheads) Select Gas wellhead for Bin III (1 Gas Wellhead)
October 15 – November 15	Collect Data for Bin II (2 Gas Wellheads) (7 total group II gas wellheads) Select Gas wellhead for Bin III (1 Gas Wellhead)
November15–December 15	Select Final Gas wellhead from Bin III Collect data for all Bin III Gas Wellheads (7 total Bin III Gas Wellheads) First MATLAB plot for Bin I and Bin II
December 15 – January 15	Final MATLAB Plotting for Bin III
January 15 – February 15	Present final findings at Florida Undergraduate Research Conference 2018

Timeline

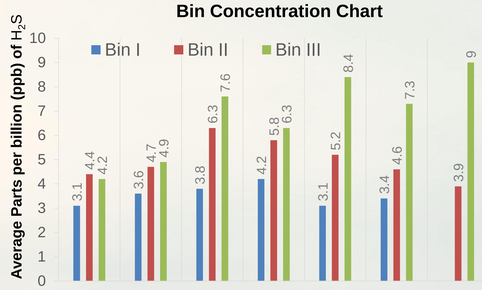


Figure 1: Shows the expected field hydrogen sulfide concentrations for each of the twenty representative gas well heads.

Discussion

- It is expected that the H_2S concentration data sampled during the seven months of field collecting will be similar to the results provided in figure 1 above.
- Based upon a preliminary field trip with landfill operators, the hypothesis that bin 3 gas wellheads will produce the highest rates of H_2S emissions is expected to be supported.
- By understanding the relationship between gas wellheads and hydrogen sulfide emissions, landfill operators can better gauge where H_2S emissions are coming from.
- The findings of this project will contribute to formulating solutions to the challenge of nuisance odor detection near landfills.

Future Work

- Future work for this research project will involve using different modeling software such as AERMOD to map hydrogen sulfide emissions.

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Acknowledgements

The authors would like to thankfully acknowledge the National Science Foundation, the Office of Undergraduate Research at Florida Atlantic University and the entire LEARN ™ staff for all the funding and support received during the development of this project. In addition special acknowledgement will be giving to the Hinkley Center for Solid and Hazardous Waste Management for their support and funding.