

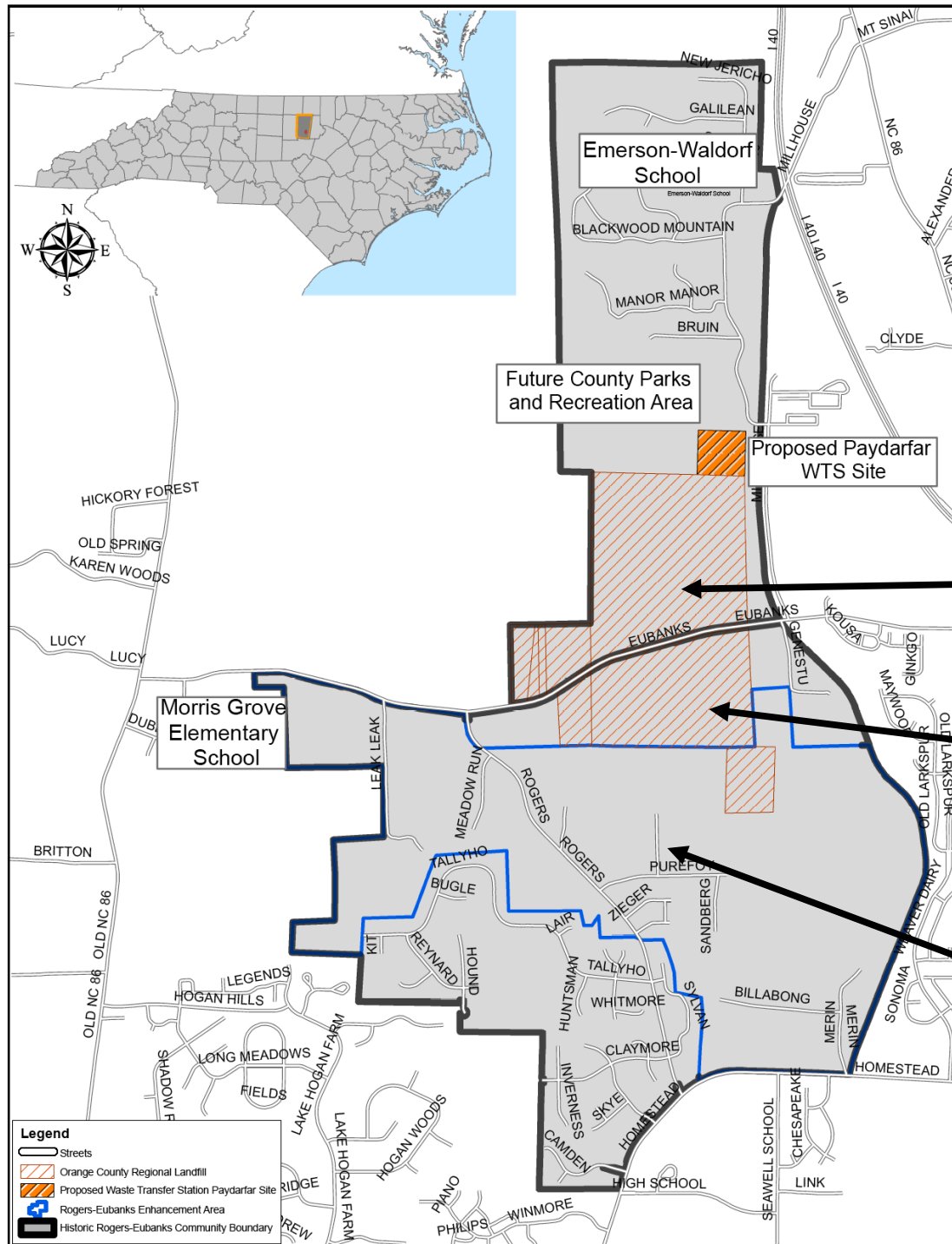


Municipal solid waste, public health, and environmental justice

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Environmental Epidemiology – EPID 785

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Rogers-Eubanks Road

African-American community
4 miles north of UNC campus

1972 unlined landfill sited
north of Eubanks Rd

1995 lined landfill sited
south of Eubanks Rd

Historic Rogers-Eubanks
community

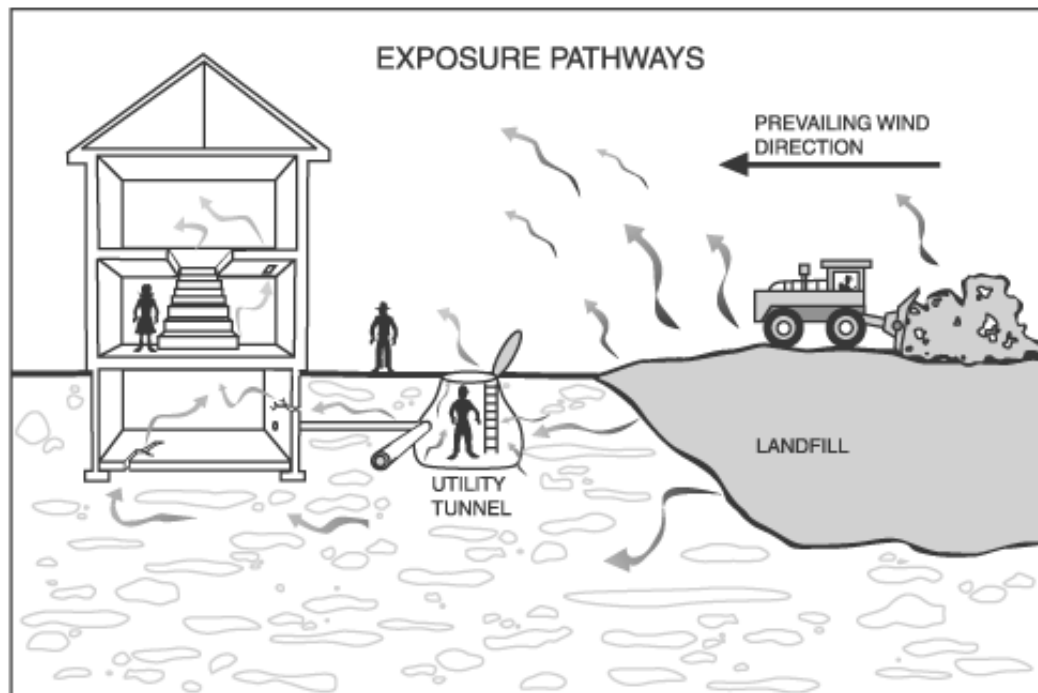
Concerns related to MSW landfills in Rogers-Eubanks community

- **Odor and air quality, stress, and health**
- Lack of safe water and sewer infrastructure
- Drinking and surface water contamination
- Cancer, diabetes, liver and kidney failure
- Illegal dumping
- Buzzards and vermin
- Safe closure of landfill
- Truck traffic
- Noise



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Landfill malodor and health



- Decomposition of organic wastes in landfills produces a complex mixture of gases
- Hydrogen sulfide (H_2S): distinct rotten egg smell, associated with anaerobic decomposition process in landfills
- Relative to methane and carbon dioxide, landfills produce small amounts of H_2S

- H_2S is marker of complex mixture of odorant and irritant chemicals
- Previous landfill odor and health studies had limited environmental measures



Organizing for community-driven research



Research questions and design

- What is the ambient level of H_2S in community bordering a landfill?
- What is the frequency and intensity of reported landfill odor?
- What is the relationship between:
 - H_2S and odor?
 - Odor and changes in daily activities, stress, negative mood states, and irritant and physical symptoms?
- Longitudinal study design of acute outcomes:
 - Adults (≥ 18 yr) within 0.75 mi of Orange County, NC regional landfill
 - Recorded landfill odor and rated symptoms 2x-daily (morning & evening) for 14 d
 - Concurrently, H_2S recorded in community every 15 min

Single point monitor
(SPM)



Thermo 450C
 SO_2 - H_2S analyzer

Analysis approach

- Repeated measures of acute/transient events
- Each participant serves as own control (fixed/
time-invariant characteristics)
- Fixed effects linear regression models:
 - Adjusted for time of day (morning/evening) of
diary record
- Effect measure modification by wind direction:
 - Northerly towards community
 - Otherwise

Twice daily diary – landfill malodor

Day 1: _____ MORNING

Part II. Go inside. Complete Steps 4-7

STEP 4. Record time when timer goes off after 5 minutes outside. Be sure to use the study clock when you record the time.



Record Current Time	Circle AM or PM
____:____	AM
	PM

STEP 5. Describe odor when you were outside. During the 5 minutes that you spent outside, did you notice any odor from the landfill? If **no**, check *none*, and proceed to Step 4. If **yes**, check the box that best describes the level of odor from the landfill during the 5 minutes you spent outside, describe what the odor smelled like, and mark whether the odor was continuous or came and went.

None ▼	faint ▼	moderate ▼	strong ▼	very strong ▼		Was the odor continuous or did it come and go?
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Please describe what the odor smelled like.	<input type="checkbox"/> Continuous <input type="checkbox"/> Come and go

Twice daily diary – mood states

Day 1: _____ MORNING

STEP 6. Record feelings. How do you feel now? Check the box that best describes how you feel *after spending 5 minutes outside*. Important: If you do not have any of the feelings described below, please mark *not at all*. There should be a box marked for every feeling described in the table.

	not at all ▼	a little ▼	moderate ▼	a lot ▼	extreme ▼
Stressed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nervous or anxious?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gloomy, blue or unhappy?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Angry, grouchy or bad-tempered?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Confused or unable to concentrate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Twice daily diary – physical symptoms

Day 1: _____ MORNING

STEP 7. Record symptoms. Do you currently have any of the following symptoms? Check the box that best describes the extent to which you are experiencing each symptom, if at all. Important: If you do not have a symptom, please mark *none*. There should be a box marked for every symptom listed.

	none ▼	mild ▼	moderate ▼	severe ▼		none ▼	mild ▼	moderate ▼	severe ▼
Excessive cough	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ringing in ears	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Runny nose or congestion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Burning, tearing, or irritated eyes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sore throat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Burning or irritated nose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Difficulty breathing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Burning or scratchy throat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Loss of appetite	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Skin irritation or redness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nausea or vomiting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Ulcer or boils on skin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diarrhea	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Round patches or scaly areas on skin (coin-sized)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trouble urinating	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	White or moist areas on skin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
General ill feeling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Rash with spots or bumps	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fever or chills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Itching	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Headache	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Other symptom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light headed or dizzy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Please describe symptom: _____ _____ _____			

What is frequency and intensity of H₂S and reports of landfill odor?

Demographics (24 participants)

- Median age: 55 yr (18-78 yr)
- 96% African-American
- 50% female
- 58% grew up near landfill

H₂S and odor measures

- 1-h avg H₂S: 0.22 ppb (0–2.30 ppb)
- H₂S present: 586 (72%) diary periods
- Odor reported: 213 (26%) diary periods

	N (%)
Total no. of diary records	900 (100)
Total no of odor ratings	820 (91)
No odor	607 (67)
Faint odor	103 (11)
Moderate odor	45 (5)
Strong odor	57 (6)
Very strong odor	8 (1)

Is there an association between H₂S and landfill odor?

	No. of records	1-hour mean H ₂ S (SD)	Beta [*]	SE	t-Value
H ₂ S (ppb)	817	0.22 (0.27)	0.3	0.11	2.75
Wind direction (Toward community)	153	0.36 (0.36)	0.67	0.19	3.5
Wind direction (Otherwise)	664	0.19 (0.24)	0.08	0.14	0.58

*Fixed effects linear regression models adjusted for time of day (morning/evening) of diary record. SD=standard deviation; SE=standard error.

What is the relationship between landfill malodor and symptoms?

Outcome	No. of records	Odor as a binary variable OR (95% CI)
Had to change daily activities because of landfill odor	817	10.2 (3.8, 27.3)
Did things differently because of landfill odor	819	8.6 (3.4, 22.0)
Mood states		
Stressed	817	2.1 (1.2, 3.8)
Angry, grouchy, bad-tempered	819	3.9 (1.8, 8.5)
Weary, bushed, exhausted	818	1.8 (0.8, 4.0)
Gloomy, blue, unhappy	818	3.1 (1.6, 6.1)
Nervous or anxious	819	2.5 (1.3, 5.0)
Active, energetic, peppy	819	0.6 (0.2, 1.5)
Mucous membrane irritation		
Burning eyes	818	5.3 (2.5, 11.6)
Burning nose	818	5.0 (2.5, 10.2)
Burning throat	818	3.3 (1.5, 7.1)
Upper respiratory		
Cough	820	2.0 (1.0, 3.9)
Difficulty breathing	820	1.9 (0.9, 4.2)
Runny nose	820	2.6 (1.4, 4.9)
Sore throat	820	1.9 (0.8, 4.2)
General ill feeling	820	2.7 (1.1, 6.6)
Headache	820	3.3 (1.5, 7.4)
Dizzy or lightheaded	818	4.1 (1.3, 12.5)

Alteration of daily activities:
ORs range: 8.6, 10.2

Stress & neg. mood states:
ORs range: 1.8, 3.9

Lack of association

Mucous membrane irritation:
ORs range: 3.3, 5.3

Upper respiratory:
ORs range: 1.9, 2.6

Other symptoms:
ORs range = 2.7, 4.1

Relationship between landfill malodor and grouped symptom categories

Index variable	No. of records	Binary odor OR (95% CI)
Alteration of daily activities	819	11.5 (4.4, 30.5)
Negative mood states	819	4.9 (2.6, 9.1)
Upper respiratory	820	3.9 (2.2, 7.0)
Mucous membrane irritation	818	3.7 (2.0, 7.1)
Gastrointestinal	820	1.0 (0.4, 2.5)

Does landfill odor impact daily activities as a function of H₂S?

	No. of records	1-hour mean H ₂ S (SD)	Did activities differently because of odor OR* (95% CI)	Changed activities because of odor OR* (95% CI)
H ₂ S < 0.15 ppb (median)	404	0.01 (0.03)	1	1
H ₂ S ≥ 0.15 ppb (median)	413	0.42 (0.25)	4.1 (1.2, 14.4)	2.7 (0.8, 9.0)

*Fixed effects logistic regression models adjusted for time of day (morning/evening) of diary record.
SD=standard deviation; CI=confidence interval.

Landfill malodor and environmental justice

- Reported odor should be a better measure of the complex mixture of air pollutants than H₂S measurements
- There could be correlated errors in reporting of odor and symptoms, which may bias effect estimates of the relation between odor and symptoms
- Was little change in relation between odor and symptoms after adjustment for H₂S
- Longitudinal design controls bias from fixed characteristics of individuals (measured or unmeasured)
- There is strong evidence of health & health-related quality of life impacts of landfill malodor in a disproportionately Black community bordering a regional landfill

Impact: Sharing results with local governments...



...and the federal government



- White House
- EPA
- Health and Human Services
- CDC



Public health impact of landfill malodor:

NC, US, & globally

- NC: Solid waste facilities (n=419) are unequally distributed by class and race (Norton, EHP 2007)
- US: Over 3,500 municipal solid waste landfills
 - Longitudinal odor and health study design in other communities
 - Include H₂S as well as other air pollutants (PM, mercaptans, VOCs)
 - Measures of FEV & PEF
- Globally: China Blasts Rubbish Dumps With Deodorant
 - Beijing's 17.6 million residents produce 18,400 tons of household garbage daily, dumped in 13 landfills around the city

<http://news.sky.com/skynews/Home/Strange-News/Beijing-Blasts-Rubbish-Dumps-With-Deodorant-Cannons-As-Weather-Causes-More-Waste-To-Rot/Article/201004415616406?f=rss>

What's the solution?

Reducing volume & toxicity of waste or shifting the burden to developing nations?

- **Is India a global trash can?**
 - <http://timesofindia.indiatimes.com/india/Is-India-a-global-trash-can-/articleshow/5851954.cms>
- **2008:** 40 containers of 'mixed wastepaper' from the US confiscated after found to contain municipal waste of an eco-toxic nature
- **2009:** Nine containers of toxic waste from Malaysia, Barcelona and Jeddah imported by Excel Trading Corporation, Sree Jayajothi Cement and Harbour Petro Chem seized
- **Mar 2010:** 20 containers of trash from French colony Reunion and Greece imported by Sripathi Paper and Boards confiscated

Community-driven research partnership

- Rogers-Eubanks Neighborhood Association (RENA)
- Undergraduate and graduate students:
 - UNC Epidemiology
 - UNC Environmental Sciences and Engineering
 - UNC Daniel A. Okun student chapter of Engineers Without Borders (EWB)
 - Institute for the Environment

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